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Soil Survey
of
The Buckeye-Beardsley Area Arizona

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Bureau of Chemistry and Soils
In cooperation with the
University of Arizona Agricultural Experiment Station

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SOIL SURVEY OF THE BUCKEYE-BEARDSLEY AREA, ARIZONA

By W. G. HARPER, United States Department of Agriculture, in Charge, and F. O. YOUNGS, University of Arizona

AREA SURVEYED

The Buckeye-Beardsley area is in the central part of Maricopa County in the south-central part of Arizona. Phoenix, the State capital and nearest city, is 15 miles east of the area. The area includes the lands farmed at the present time and the adjacent desert lands for which irrigation is now (1927) being devolped. The included area is 284 square miles or 181,760 acres lying in the Buckeye irrigation district, the Roosevelt irrigation district, the Beardsley irrigation project (Maricopa County municipal water conservation district No. 1), and other large and small company and individual holdings. On the east, the area is bounded by Skunk Creek, New River, and Agua Fria River. Gila River forms the southern boundary, and Hassayampa River, the proposed location of the Roosevelt irrigation district canal, and the Beardsley Project Canal form most of the west and northwest boundaries.

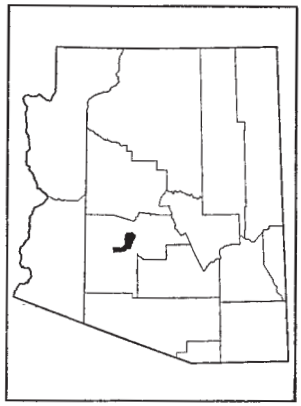

FIGURE 1.—Sketch map showing location of the Buckeye-Beardsley area, Arizona

The area is part of a smooth-surfaced gently sloping valley plain, almost unbroken by topographic irregularities and but little dissected by deeply cut streams. The greater part consists of alluvial fans that slope from rugged barren mountains, some of which are near the area, whereas others are several miles distant. These fans are exceptionally smooth surfaced and uniform in part of the area, but in other parts they are slightly ridged, the ridges being separated by drainage channels of small intermittent streams. The slope ranges from 15 to 50 feet, but in a large part of the area averages about 30 feet to the mile. The uniformity of the fan slopes is broken in the east-central part of the area, where about 4 square miles of comparatively rough and dissected ridges of old unconsolidated materials protrude from 15 to 30 feet above the valley floor. The relief is broken again where flat bottom lands, rolling or hummocky lands, and a continuous low swale parallel Gila River in a strip ranging from one-quarter to 1½ miles in width. The highest point, 1,330 feet above sea level, lies in the northwest corner of the

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area and the lowest, about 760 feet, occurs along Gila River at the southwest corner.

Gila River receives the drainage waters. The regional drainage is good, and surface drainage is well defined in some parts of the area but poorly defined in others. Throughout most of the alluvial-fan areas, flat slightly depressed drainage ways and small steep-sided stream channels serve as surface drainage courses for flood waters, which are occasionally augmented by large flows of drainage waters from adjacent higher-lying lands. The larger streams touching the area have comparatively wide bottoms. Gila River is the only perennial stream. In the northeastern part of the area the streams are deeply cut, whereas toward the southwest they are but a few feet lower than the adjoining lands.

The Buckeye-Beardsley area lies within Maricopa County, which was organized from parts of Yavapai County in 1871. The population increases with irrigation development, irrigation being necessary for crop production. Settlement began with the beginning of irrigation and has been restricted to the area where irrigation is practiced. The Buckeye irrigation district, in which about 16,000 acres are irrigated at present (1927), has a population of about 1,700, all of which may be classed as rural. Other sparsely settled districts occur near or to the south of the highway in the southeastern part of the area and along the Agua Fria River and the adjacent lower-lying lands. Development by the Southwest Cotton Co. has brought about settlement in the vicinity of Litchfield Park and Marinette, located on company lands in the east-central and northeast parts of the area, respectively. The population of Litchfield Park is about 200 and of Marinette 150, with twice as many in cotton-picking season. The Buckeye irrigation district and small privately operated farm areas are settled almost wholly by American-born whites, whereas the labor on the large acreages (17,500 acres at Litchfield Park and 10,848 acres at Marinette) farmed by the Southwest Cotton Co., is performed principally by Mexicans. Other towns of the area are Buckeye, in the southwest part, and Coldwater in the southeast part. Buckeye is an important agricultural town in the Buckeye irrigation district and is the site of both grade and high schools and a cotton gin. Palo Verde and Liberty, in the southern part of the area, are small farm and school centers.

The main line of the Southern Pacific Railroad gives direct service to coast cities and to cities of the East. A branch line runs north from Litchfield in the southeast part of the area to Litchfield Park, an agricultural center 5 miles north. A branch line of the Atchison, Topeka & Santa Fe Railway gives direct service between Phoenix and Los Angeles and other coast cities. Another branch of the same line is now (1927) under construction in the northwest part of the area.

Two concrete paved highways, one paralleling the Atchison, Topeka & Santa Fe Railway and the other roughly paralleling the Southern Pacific Railroad, cross the area. A branch paved road leaving the highway near Litchfield, runs north 4 miles, terminating at Litchfield Park. Secondary roads have been provided on the

section lines in many parts of the area. Drinking water is obtained from wells and in general is moderately soft and pure. Water from a few wells is high in soluble salts.

Hydroelectric transmission lines furnishing power for pumping and light for home use parallel roads and section lines through the northeastern and eastern parts of the area.

CLIMATE

The Buckeye-Beardsley area is in a warm, dry region. The climate is characterized by high maximum and mean temperatures, long, hot summers and short, exceptionally mild winters, low relative humidity, and rapid evaporation. Killing frosts occur during only a short period of the year in the lower part of the area and are of rare occurrence in the higher, more protected parts. The percentage of sunshiny days is large, the average wind velocity is low, hail, fog, or destructive winds are very rare, and snow is unknown. The daily range in temperature is great, the average difference between the mean maximum and the mean minimum being 28.2° F., according to records kept at Phoenix from September, 1895, to December, 1926, inclusive.

The rainfall is normally very light but varies from year to year. Prolonged droughts are of rather frequent occurrence. Most of the precipitation in average years occurs in two distinct periods, in midwinter and in late summer. Spring and fall are usually very dry. In late summer the rains occur as thundershowers.

The average dates of the latest and earliest killing frosts are March 7 and November 22, respectively, according to data of the Weather Bureau station at Buckeye. The latest recorded killing frost was on April 10 and the earliest on October 22. The long growing season allows the production, under irrigation, of a wide variety of crops of temperate and subtropical regions. Temperature is important in this area, and many individuals or companies have kept temperature records at various localities to gain information regarding frost-free areas as related to citrus production and land values. On the comparatively higher-lying lands air drainage is usually excellent, and killing frosts are infrequent.

Temperature records kept by the Southwest Cotton Co. at the northwest corner of sec. 7, T. 2 N., R. 1 W. show the mean temperatures for the winter months to be as follows: December, 36.3° F.; January, 33.3°; and February, 41.2°. Temperatures do not average so low on the higher-lying lands of the area to the northwest and southwest of the station.

The normal monthly, seasonal, and annual temperature and precipitation, as recorded at the United States Weather Bureau station at Buckeye, are given in Table 1.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Buckeye, Maricopa County, Ariz.*

[Elevation, 980 feet]

Month	Temperature			Precipitation		
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1891)	Total amount for the wettest year (1905)
	° *F.*	° *F.*	° *F.*	*Inches*	*Inches*	*Inches*
December	50.4	85	13	0.93	0	0.45
January	51.0	86	11	1.00	0	2.91
February	54.6	92	18	.77	.47	6.46
Winter	52.0	92	11	2.70	.47	9.82
March	59.3	100	25	.75	(1)	3.61
April	66.0	103	30	.28	(1)	2.04
May	73.2	113	32	.08	.10	(1)
Spring	66.2	113	25	1.11	.10	5.65
June	82.0	117	42	.06	0	(1)
July	88.3	121	51	1.14	.06	.28
August	88.1	117	54	.91	(1)	.46
Summer	86.1	121	42	2.11	.06	.74
September	81.5	113	41	.55	(1)	.58
October	68.9	114	29	.50	0	(1)
November	58.1	94	22	.77	0	5.01
Fall	69.5	114	22	1.82	(1)	5.59
Year	68.4	121	11	7.74	.63	21.80

[1] Trace.

SOIL SERIES AND TYPES

The soils of the Buckeye-Beardsley area are differentiated into soil series, which are further divided into soil types. The soil series is a group of soils having common characteristics of profile, that is, resembling each other in color, structure, and chemical composition, and in sequence, number, and degree of development of the soil layers or horizons. The soils of a series occur under similar general conditions of relief and drainage and usually have a common or similar origin and mode of formation. The soil type corresponds in all respects to the soil series of which it is a member and is separated on the basis of the texture of the surface soil, or the proportion of the various-sized soil aggregates present.

In the following pages of this report the soils of the Buckeye-Beardsley area are described in full and their agricultural possibilities are discussed; their distribution is shown on the accompanying soil map; and their acreage and proportionate extent are given in Table 2.

TABLE 2.—*Acreage and proportionate extent of the soils mapped in the Buckeye-Beardsley area, Arizona*

Type of soil	Acres	Per cent	Type of soil	Acres	Per cent
Mohave sandy loam	27,136	14.9	Gila sandy loam	11,392	6.3
Mohave fine sandy loam	10,432	5.7	Gila fine sandy loam	8,512	6.0
Mohave loam	18,624	10.2	Poorly drained phase	2,368	
Mohave clay loam	2,048	1.1	Gila silt loam	3,136	1.7
Mohave gravelly sandy loam	2,432	1.3	Gila silty clay loam	6,848	3.8
Laveen sandy loam	19,328	11.2	Gila fine sand	5,184	2.9
Heavy-textured phase	1,088		Gila clay	3,584	2.0
Laveen fine sandy loam	12,672	7.0	McClellan silty clay	3,904	2.2
Laveen gravelly loam	9,728	5.4	Pinal gravelly loam	1,280	3.0
Anthony sandy loam	3,648	2.0	Red-subsoil phase	4,160	
Anthony fine sandy loam	5,120	2.8	Pinal fine sandy loam	2,624	1.4
Anthony very fine sandy loam	1,472	.8	Rough broken land	1,024	.6
Anthony loam	2,944	1.6	River wash	7,552	4.2
Anthony silt loam	2,560	1.4	Total	181,760	
Anthony silty clay loam	960	.5			

MOHAVE SANDY LOAM

In its more typical development, Mohave sandy loam has a surface layer, about 7 inches thick, of brownish-red slightly compact noncalcareous sandy loam of fine granular structure. This material feels slightly gritty but contains both angular and rounded sand fragments of mixed origin. The underlying subsurface layer is of pronounced red loam similar to the surface layer. It is slightly compact, slightly gritty, noncalcareous or feebly calcareous, and of fine granular structure. This layer grades, at an average depth of about 15 inches, into compact, highly calcareous, finely granular, reddish-brown clay loam highly mottled with gray lime flecks. The granules are larger than in the two upper layers, many of them being nearly a centimeter in diameter. At an average depth of 30 inches, this layer merges into a deeper subsoil layer of gritty loam of gray or patchy brownish-gray color, depending on the amount of lime accumulated and its distribution or commingling with the particles of brown soil. This layer is highly calcareous, compact, and weakly cemented with lime, but the particles are firm or hard, pore space is considerable, and on wetting the aggregates are readily crushed to a structureless mass. This layer is underlain at a depth of about 6½ feet by the parent material of rich-brown friable or loose fine gravelly loam and coarse sand particles which, though highly calcareous, are free of lime mottles. The sand and gravel particles, like the other distinguishable fragments throughout the soil, are both angular and rounded and are of highly mixed, though probably predominately granitic, origin.

As mapped in this area this soil includes extensive tracts of duller reddish-brown or brown sandy loam soil which merges imperceptibly into the related brown soils of the McClellan series. In these browner inclusions the upper subsoil layer is commonly less compact than typical. It consists of friable sandy loam mottled with accumulations of lime and iron, pinkish in color when finely pulverized, but on fresh fracture showing gray lime-carbonate and a few reddish iron mottles. At an average depth of 28 inches this

horizon grades into weakly cemented, very highly calcareous pinkish-gray or gray loam, which, when struck with a hammer, breaks into irregular-shaped chunks and many smaller irregular-shaped lime-cemented fragments or nodules. On wetting, the material is easily pulverized to a loose friable mass. At a depth of 4½ or 5 feet this layer grades into the brown, highly calcareous, rather friable gritty sandy loam parent material.

Other variations from typical occur in many localities where this soil lies adjacent to recent soils. In many such places the surface soil has been covered by a deposit, increasing the depth to the subsoil. In a few small included patches near the margin of the area in secs. 9 and 4, T. 2 N., R. 2 W., a number of gravel and stones occur. In sec. 4, T. 2 N., R. 2 W., the area of soil lying between the lower stretch of gravelly material and along the edge of the area of Mohave sandy loam to the east is composed of deposits of typical Gila sandy loam, from 2 to 4 feet thick, overlying materials similar to Mohave sandy loam. A similar area about 500 feet in width and extending about one-third of a mile northwest and southeast of the section line, occurs about one-half mile west of the southeast corner of sec. 34, T. 2 N., R. 2 W. A similar area occurs in sec. 25, T. 2 N., R. 2 W., reaching to the north limits of the area of Mohave loam just south of this point. The latter two areas have been mapped with the Gila sandy loam.

This is a mature soil that has resulted from the weathering of well-drained alluvial-fan materials that have been transported by water for moderate and long distances. Igneous, basaltic, granitic, rhyolitic, and sedimentary quartzitic rock fragments are distinguishable in the materials of the redder areas, but the parent materials in the browner areas seem to be mainly granitic. The granitic and quartz particles are angular, but many other particles are well rounded.

This is the most extensive soil in the area. The largest tract is northwest of Buckeye, adjoining the Laveen soils on the east, and several small or moderately large areas occur north and northeast of Perryville. This soil occurs on broad, exceptionally smooth and uneroded alluvial fans which slope uniformly from 20 to 40 feet to the mile and which consist of materials from the White Tank Mountains, a rugged range of barren mountains, lying a few miles beyond the boundary of the surveyed area. The redder soil occurs on old fans or ridges slightly above the finer-textured soils and on less pronounced ridges or slopes below coarser-textured soils. Most of the areas are rather narrow, extending in strips from one-half to 3 miles long.

The surface soil absorbs moisture readily, but during heavy rains surface waters gather in shallow drainage ways that course down the slopes. Internal drainage is usually favorable under irrigation, although at lower depths there may be impervious barriers that force the ground water near the surface. That part of the soil west of Litchfield Park is high lying, and no poorly drained areas should develop in it. This applies also to the higher-lying lands north of Buckeye. No poorly drained or alkali-affected areas occur within the soil at present.

Very little of this soil is now cultivated, owing to its location mainly where irrigation has not yet been developed. The small

area cultivated is producing good yields of cotton, alfalfa, and grain. Small plantings of grapes, grapefruit, and dates, not yet in bearing, have been made. The undeveloped or desert lands support a rather dense growth of creosote bushes that grow from 4½ to 6 or more feet high, and in places there is a thick growth of bur sage. Plantain, alfilaria, and a 6-weeks' grass make a good growth following periods of appreciable rainfall. Paloverde, ironwood, and mesquite are common along the shallow drainage ways. A few giant, cholla, and smaller varieties of cactus are seen.

This is a desirable soil which in other areas in the State has proved suited to a large variety of crops, including alfalfa, cotton, grains, sorghums, sweetpotatoes, grapes, citrus fruits, and dates. This soil should prove one of the best in the Roosevelt irrigation district and undoubtedly will be desirable in the Beardsley irrigation project where nearly all of it occupies a favorable location with regard to air drainage and freedom from frost. It is very low in organic matter, and the plowing under of green manures would increase its productiveness.

MOHAVE FINE SANDY LOAM

The surface layer of Mohave fine sandy loam is apparently a recent deposit over a normal Mohave soil. The upper layer, which ranges in thickness from a few inches to as much as 3 feet but averages about 20 inches, consists predominantly of rich-brown or pale reddish-brown firm but friable micaceous and mildly calcareous fine sandy loam. The underlying material differs in texture but is very similar in color and development to that in corresponding layers of Mohave sandy loam. As mapped, a few small areas in which the surface soil is of very fine sandy loam texture have been included. Such areas occur in the vicinities of Coldwater and Litchfield Park.

Near Litchfield Park the areas of this soil grade into adjoining areas of Laveen fine sandy loam, and the boundary line between the two soils is more or less arbitrary. The area at Litchfield is calcareous in the surface soil, which in a few places contains a few small lime nodules. The soil occurs on very smooth, broad, and comparatively level alluvial-fan slopes below coarser-textured soils. The slope of the fans ranges from 20 to 30 feet to the mile. Drainage is moderately well developed. No poorly drained or alkali-affected areas occur at present, or is it likely that such conditions will develop extensively following irrigation in this vicinity. Some seepage and alkali accumulation may result locally on slopes where free waters seep out.

Mohave fine sandy loam is rather extensive in this area. It is estimated that nearly half of it is cultivated. Plants on virgin areas, crops grown, and soil management and adaptability are similar to those of Mohave sandy loam.

MOHAVE LOAM

To a depth of 6 inches, Mohave loam consists of light chocolate-brown or rich-brown noncalcareous compact loam of clod or small clod structure. The next lower layer, which typically is about 8 inches in thickness, is brownish red or dull red and mildly calcareous

but is similar to the surface soil in texture and structure. Between depths of 14 and 20 inches the material is brownish-red, granular, gritty clay loam mildly or moderately calcareous and slightly more compact than the layers above. This layer is more plastic than the overlying layers and is apparently higher in colloidal material. Below a depth of 20 or more inches the material is gray very highly calcareous gritty loam weakly or rather firmly cemented by lime. This material is hard when dry, but when wet it readily absorbs water and is easily crushed to an incoherent mass. It is underlain at a depth of about 4½ feet by the somewhat modified grayish-brown or brownish-gray, highly calcareous, and weakly lime-cemented parent material of coarse sandy loam containing much fine gravel. At an average depth of 5½ feet the unmodified parent material occurs. This is of reddish-brown color, is moderately calcareous, and in texture averages coarse sandy loam or fine gravelly loam. In a freshly cut exposure it stands up and seems rather firm, but it is easily broken or crushed to an incoherent mass.

This is an old soil weathered from accumulated deposits that have been transported by water some distance from their place of origin. In the areas in the vicinity of and to the north, northeast, and northwest of Litchfield Park the gritty and distinguishable mineral materials are derived from a variety of rocks and have apparently been transported from the Bradshaw Mountains. In those areas west and southwest of Litchfield Park the distinguishable mineral material is purely granitic, and the fragments are very angular. The material of these areas has come directly from the White Tank Mountains only a few miles distant from the area and in them the surface soil and subsurface soil are not so compact as is typical. Also the horizon of lime accumulation is not quite so pronounced. In a number of localities the subsoils are characterized by the occurrence of heavy-textured, rather tight and compact brownish-red clay from a few inches to as much as 3 or more feet in thickness, which begins at a depth ranging from a few inches to 2 feet below the surface. This material occurs in parts of the soil area about 7 miles north of Litchfield Park and in much of the area extending north from a point about 3 miles northwest of Litchfield.

The tract along the north boundary of the surveyed area 2 miles east and 1 mile north of Beardsley consists of a recent silt loam overwash, from 2 inches to 2 or more feet in depth, over a normal Mohave soil. Similar tracts occur in the north and north-central parts of the area in the lower depressions between ridges of lighter-textured soils and in the large flats. The intermittent desert streams have dropped the coarse sediments of their load proportionately as the volume and velocity of the flow decreased. Thus the fine sediments were carried on down the slope and deposited on the flats where the waters have spread out. Areas are exceptionally smooth, the slope being from about 18 to 30 feet to the mile. Surface drainage is not well developed, and flood waters often stand on the surface in the low parts of the areas. Subsoil drainage also is very poorly developed in most areas. In areas west and southwest of Litchfield Park internal drainage is good. Nearly all the areas north of Litchfield Park contain some mineral salts but in most

places not in sufficient quantities to be harmful to crops. Much of the southern part of the tract that extends north from a point about 3 miles northwest of Litchfield Park is impregnated with mineral salts in sufficient amounts to affect crops slightly.

Only a small proportion, about 4 square miles, of this soil is farmed. Alfalfa, cotton, and grain are the principal crops grown, and moderate or good yields of each are reported. The soil north of Litchfield Park contains larger quantities of colloidal material than that west and southwest of this place. This more plastic soil clods considerably following plowing and requires considerable cultivation if the seed bed is to be properly prepared.

Growing alfalfa on this soil helps somewhat to open the subsoil. Following extensive irrigation above the low-lying areas near and north of Litchfield Park, some seepage waters may appear and drainage may be necessary to protect the land from becoming waterlogged and affected by accumulations of alkali salts.

MOHAVE CLAY LOAM

The 12-inch surface layer of Mohave clay loam consists of reddish-brown mildly calcareous compact clay loam rather high in silt and in some localities approaching silty clay loam in texture. This material is rather sticky and apparently is high in colloids. When dry it breaks into hard clods; when moist it breaks easily into small particles; and when wet it has a tendency to run together and pack with but small pore space. The next lower material is brownish-red mildly or moderately calcareous compact heavy clay loam or clay slightly more compact than the material above, containing a larger proportion of fine material, and being rather tight and only slowly pervious to water. This layer extends to an average depth of 26 inches, where it grades into highly calcareous, compact clay loam of rich-brown basic color patched with many gray mottles of lime accumulations. At a depth of 3½ or 4 feet this horizon merges with light-brown or pinkish highly calcareous, compact clay loam in which the lime is evenly distributed. In origin and character of material this soil is similar to Mohave loam.

The largest area of Mohave clay loam occurs just south of Litchfield Park. Very small areas are about 1 mile northeast and about 2 miles north of Litchfield Park, near Ennis, northwest of Beardsley, about 1 mile south of the Atchison, Topeka & Santa Fe Railway between Beardsley and Ennis, and about 2¼ miles southwest and about 6 miles south of Beardsley. The soil occurs below related soils of lighter texture and generally in association with soils of loam texture. Areas are exceptionally smooth and generally slope very gently down the fans between 20 and 25 feet to the mile. Surface drainage is poorly or moderately well developed, and subsoil drainage is greatly impeded by the partly impervious layers of heavy texture. Although the soil contains considerable soluble salts, the concentration in most places is not harmful at the present time. In the area about 2 miles north of Litchfield Park and the lower part of the area south of Litchfield Park, however, the salts affect crops slightly.

The area of this soil south of Litchfield Park is farmed to alfalfa, barley, and cotton. Yields are only fair, as compared with those

on the Mohave and Laveen fine sandy loam types near by. On 61 acres, this soil produced 3 tons of alfalfa hay to the acre and some pasturage, and a 56-acre field on Laveen fine sandy loam produced 8 tons of hay to the acre. The duty of water was about the same on both soils, the sandy soil taking much more water and returning higher yields. It was impossible to get much water into the heavier-textured soil.

This soil is plowed when moist enough to be rather cheeselike, is allowed to dry until it can be worked without packing, and is then disked and harrowed to the desired seed-bed condition.

MOHAVE GRAVELLY SANDY LOAM

The surface of Mohave gravelly sandy loam, as it occurs in this area, is covered by a layer of angular gravel of granitic origin. The fragments range in size from fine to 1½ inches or more in diameter. The gravel is of rather fresh fracture and free from oxidized or stained surfaces. It has washed from the White Tank Mountains and accumulated on the surface of this soil; it does not extend below the surface. Directly beneath this gravelly layer is pinkish or brownish-gray moderately calcareous friable sandy loam continuous to a depth of about 7 inches. This material grades into brownish-gray, highly calcareous, slightly compact, light-textured loam which continues to a depth of about 20 inches where it is underlain by uniform-textured, compact, highly calcareous, granular material, principally brownish-red or reddish-brown in color but somewhat mottled with gray lime flecks. At an average depth of 4 feet this grades into the lighter brownish-red or reddish-brown, moderately calcareous, slightly compact, but friable light loam parent material.

This is an old soil developed from water-transported deposits that had their origin in rocks of granitic origin in the White Tank Mountains. The soil materials are sharp edged and angular, as they have been transported only a few miles. The surface soil deviates from the normal soil profile of the region in being moderately calcareous. Most of the soil occurs on comparatively steep (about 70 feet slope to the mile) old alluvial fans built up by streams emerging from mountain canyons a few miles away. The tracts farther down the slope and the patches in the southwestern part of the area, however, have moderate slopes, about 30 feet to the mile. Where this soil is most extensive northwest of Litchfield Park, it is dissected by a number of gradually sloping intermittent arroyos from 3 to 10 feet deep, which give rise to a rather choppy and rolling relief. Near the lower edges of these tracts and in the areas near Conger the surface is comparatively smooth and gently sloping. Surface drainage ways are well developed, and erosion by surface waters entering from the higher fans is still in progress. Internal drainage is very good, and no areas are harmfully affected by mineral salts or alkali.

This soil is used agriculturally only for grazing. It is covered with a scattered growth of creosote bush about 2 feet in height, some bur sage, and giant, cholla, and other cacti. A few mesquite and paloverde trees are to be seen along the arroyos, and a small growth of six weeks' grass and plantain furnishes scant grazing.

Where this soil can be leveled at a reasonable cost, following the delivery of water through canals now being constructed, it will be desirable in many respects. The area northwest of Litchfield Park is favorably located with regard to air drainage and freedom from frosts and will probably be desirable for citrus fruits and other crops under irrigation. The soil is suited to the production of nearly all crops grown in the surrounding cultivated areas. It is low in organic matter and will respond to any practice that will result in the increase of this material.

LAVEEN SANDY LOAM

The 14-inch surface layer of Laveen sandy loam consists of light pinkish-brown or grayish-brown, friable, highly calcareous sandy loam of either mixed or granitic origin. The soil material is rather micaceous and contains either angular or rounded sand particles or a mixture of the two and a number of gray lime nodules of irregular shape and ranging in size from that of a pin point to 4 millimeters in diameter. When an exposed bank is dug into, the nodules crumble easily to fine separates. This layer is underlain by gray nodular or fragmentary, hardpanlike, very highly calcareous loam consisting of a mass of weakly or firmly cemented lime nodules, many of which on breaking are irregular in shape, owing in part to included small gravel or sand particles cemented in the material, and many of which are roughly spherical. The nodules range from the size of a pinhead to an inch or two in diameter. This material seems hard when bored into with the soil auger and becomes very hard on exposure to the air and sun but is partly open so that fine plant roots and water enter between the nodules. This layer ranges from about 10 inches to 3 feet or rarely more in thickness and is underlain by a modified horizon of parent material of brownish-gray highly calcareous compact sandy loam free from nodules. This layer is rather compact but is probably softly cemented. It breaks into irregular chunks or clods, depending on the manner in which it is struck. No regular cleavage planes are apparent, but to a minor extent lines of fracture follow the nodules. This modified parent horizon differs slightly in thickness from place to place but averages about 18 inches. It grades into the unaltered parent material of rich-brown friable moderately calcareous sandy loam or loamy sand of rather open structure or with no discernible structure.

This is an old alluvial-fan soil that has been transported, deposited by water, and later greatly modified by weathering agencies. Following weathering to a normal profile, the surface soil has probably been eroded, leaving the present surface soil, which is very high in lime. The surface texture of much of the area in the vicinity of Marinette is slightly heavier than that of other areas, owing to the very slight silting of the surface soil from muddy water diverted from Agua Fria River and used for irrigation.

This is a very extensive soil. The largest area occurs around Marinette, and many patches are mapped elsewhere, especially in the south-central and southwest-central parts of the surveyed area. The soil occurs on the slightly elevated ridges or between ridges occupied by Laveen gravelly loam. In the southwest-central part of the

area, where this soil is largely associated with Laveen gravelly loam, many long comparatively narrow tracts occur. Most of the areas are very smooth surfaced, with a general slope of about 25 feet to the mile or slightly more. Surface and internal drainage are well developed, and although the subsoil does not allow rapid movement of percolating waters it does not retard the necessary drainage under irrigation. No poorly drained areas or harmful alkali accumulations exist at present.

About 50 per cent of this soil is cultivated. The remainder is located in areas where irrigation water has not yet been economically provided. The undeveloped lands support a growth of scattered creosote bushes about 4 feet in height, desert sage, bur sage, and cacti. Some plantain and grasses furnish scant pasturage. The farmed area is utilized principally in the production of cotton and alfalfa, but plantings of olives, figs, grapes, Sudan grass, and truck crops have been made. Alfalfa and cotton do well, the olive trees are moderately thrifty, and good yields of grapes and fair yields of garden truck are reported.

This soil is plowed when moist and is easily worked to a desirable seed bed by harrowing and disking as soon as it dries enough to cultivate. Bordering and furrowing are necessary in preparing for irrigation, depending on the crop to be grown. Irrigation is necessary for all crops. No fertilization practices are followed. Cotton is grown year after year or cotton and alfalfa are rotated, the alfalfa being left four or five years and followed by cotton.

Laveen sandy loam, heavy-textured phase.—Laveen sandy loam, heavy-textured phase, differs from typical Laveen sandy loam only in having a surface layer of dark-brown or brown mildly calcareous loam. This layer has been accumulated from fine sediments deposited from muddy irrigation water. It is higher in organic matter than the soil on which it has been deposited and on wetting becomes dull or dark chocolate brown in color. The layer of recently deposited material ranges in depth from a mere film which can hardly be detected to about 12 inches.

The surface texture in the two areas mapped west of Palo Verde averages clay loam and the subsoil is lighter than typical in texture, averaging sandy loam in the upper part and loam in the lower.

This soil is mapped in one area of about 700 acres about 1½ miles northwest of Marinette, in a number of small bodies in the same vicinity, and in two small areas about a mile west of Palo Verde. The outlines of the larger area are determined by fence lines marking limits of the land on which the muddy irrigation waters were applied. The smaller areas occur in low slightly depressed drainage areas. All the soil has been leveled and farmed. Areas are exceptionally smooth, sloping about 20 feet to the mile. Surface drainage is cared for on irrigated lands by waste ditches; internal drainage is somewhat retarded but appears to be adequate under existing agricultural conditions.

Alfalfa and cotton are grown, with acre yields of about a bale of upland cotton and two-thirds bale of Pima cotton, and about 3 tons of alfalfa in addition to considerable pasturage.

This soil is very easily tilled and pulverized to a desired seed-bed condition. It is plowed when moist, disked and harrowed, and

floated and bordered for irrigation with farming machinery especially suited to these purposes.

LAVEEN FINE SANDY LOAM

The profile of Laveen fine sandy loam is very similar to that of Laveen sandy loam, but each layer is finer textured. A gravelly area northeast of Coldwater is indicated on the map by gravel symbols.

The largest area of this soil is west of Coldwater. Other tracts occur in and about Litchfield Park and north of Marinette, and a few patches are mapped near and to the southwest of Agua Fria. Most of the areas are slightly ridged or very gently rolling, having a fall of about 25 feet to the mile. Included ridge slopes are of slightly greater gradient. The surface soil is friable and uncompacted and readily absorbs moisture, but as much of the rain falls as heavy thundershowers a large part of it runs over the surface to lower levels. Surface drainage is well developed, and internal drainage is adequate to care for downward percolation of irrigation water. No poorly drained areas or alkali accumulations occur within the soil.

More than 90 per cent of this soil has been cultivated to alfalfa, cotton, wheat, barley, grapes, and potatoes. Yields are similar to those on the average producing soils of the near-by cultivated districts. This is a very easy soil to cultivate. It may be plowed when moist or dry. Plowing, disking, floating, and preparation for irrigation are easily accomplished with tools designed for such purposes. No crop rotations are followed, and no fertilizers are used.

The desert areas support a moderate growth of creosote bush from 3 to 5 feet in height and in places a rather dense growth of desert sage. Plantain or Indian wheat, some alfilaria, and a 6-weeks' grass grow to a small extent following rainfall, yielding scant pasturage. The soil is very low in organic matter.

LAVEEN GRAVELLY LOAM

The profile of Laveen gravelly loam differs from that of Laveen sandy loam only slightly. The surface soil, in the virgin condition, consists of light brownish-gray or pale grayish-brown, highly calcareous, slightly compact but friable gravelly loam in which a pinkish or pale-reddish tint persists in most places. The gravel is mixed in origin and angular and subangular in shape. Part of the surface gravel has a characteristic dark desert polish or desert varnish. Many lime-carbonate nodules, averaging about the size of a small pea, are present on and in the surface soil which varies somewhat in depth, in many places being only 4 inches thick but in a few places reaching a depth of 2 feet. The average depth is between 6 and 12 inches. This material is underlain by a horizon of gray gravelly loam, very highly calcareous and weakly or firmly cemented by lime. When this layer is broken, the aggregates are of various sizes. Irregular nodular fragments from 2 to 5 millimeters in diameter probably predominate, and the embedded gravel usually break out singly, each retaining a thin gray calcareous coating. This layer

ranges in thickness from about 8 inches to 4 feet but averages about 2 feet. It grades into a layer of less modified material, the upper layer of the parent material. This consists of grayish-brown, loamy, gravelly sand weakly cemented by lime and very highly calcareous but not carrying many lime nodules. This layer, which is in most places about 18 or 20 inches thick, grades into the deeper parent material of friable, rich-brown, gravelly, sandy material which in general is moderately or highly calcareous but free from lime nodules but which in places is free from gravel or is of much heavier texture. In a number of exposures along deeply cut arroyos north of Hassayampa heavy, compact, greenish-gray clay, very high in salt, underlies the soil at a depth ranging from 4 to 8 feet. This old clay appears to be of lake-laid origin.

This soil has been formed from weathering of old alluvial-fan deposits. In the areas near Hassayampa River and in the northeastern part of the surveyed area the deposits are derived from a variety of rocks, but in the areas occurring in the southwest-central part of the surveyed area the parent materials are of granitic origin. The deposits, which are of mixed origin, have been transported great distances, probably from the distant mountains north of the area, and the gravel is well rounded and waterworn. The granitic material has been transported only from the White Tank Mountains, and in it the gravel is angular. The deposits have weathered following deposition, and a large proportion of lime has accumulated in the subsoil.

This soil differs from a normal desert soil in containing many lime-carbonate nodules in the surface soil. This may be owing to removal by erosion of an original surface soil, leaving the normal subsoil of lime accumulation exposed, or it may be owing to the accumulation of lime at the surface from the evaporation of lime-impregnated seepage waters.

This soil is widely distributed over the area. It occurs typically on slight ridges and on the fan slopes where erosion has removed much of the fine surface soil. Most areas are somewhat rolling. The ridges in the southwest part of the area are long and narrow, many of them being but a few hundred feet in width and from one-half mile to 2 miles in length. On the fan slopes near the rivers the soil covers large areas that are cut and dissected by streams, leaving many steep banks sloping to intermittent stream ways from 10 to 30 feet below the general surface. Near the breaks or on the eroded slopes the cemented subsoil is in many places very near to or exposed at the surface.

Surface drainage is well developed, and internal drainage is moderately good. No areas of harmful accumulations of alkali are present. Some plantain and 6-weeks' grass grow naturally over much of the soil, giving it a slight pasture value. It supports a scattered growth of creosote bush and a few mesquite, paloverde, and ironwood trees along the intermittent drainage ways.

Although this soil is not farmed, parts of it will be tilled when irrigation water becomes available. It is not well suited to irrigation farming in this section, owing to its uneven surface relief and gravelly surface soil. The weakly or firmly cemented horizon is so near the surface that shallow or fibrous rooted crops would be more successful than tree crops.

ANTHONY SANDY LOAM

To a depth of 12 inches the surface soil of Anthony sandy loam consists of brownish-red or pronounced reddish-brown very mildly calcareous friable sandy loam. The next lower material is similar to the surface soil in all respects except its slightly greater calcareousness. A little undecomposed fine gravel and a few sand particles are present throughout the entire soil. The fragments are from mixed rocks, and some are angular and subangular, whereas others are well rounded from water transportation. The soil materials contain a small amount of colloidal material and are slightly sticky.

The area extending through sec. 22, T. 3 N., R. 1 W., the southeastern extremity of the area in the NW. ¼ sec. 27, T. 3 N., R. 1 W., the area 2 miles south and 1 mile east of Beardsley, and the body crossing the railroad at Ennis are of fine gravelly loam texture.

This soil is mapped only in the northwestern part of the area surveyed. It is derived from sediments undoubtedly having their source in the Bradshaw Mountains several miles northwest of the area. Stream ways course from the mountain canyons in that section down the slope to the south for several miles, where they turn southeast, passing into and through the area. These streams or similar streams have dropped sediment, building up the soils. This soil includes the coarsest-textured materials of the recent soils of that part of the area and occupies ridges that lie at elevations from a few inches to a few feet above the adjacent lands. The streams depositing the sediments flowed down the fan slope in a southeasterly direction, and the areas of the soil extend as long, narrow tracts, marking the old courses of the depositing streams.

Areas of this soil are very smooth, sloping about 35 feet to the mile. Drainage is very good, and no accumulations of alkali salts are present. Less than 50 acres of the soil is cultivated. Cotton and alfalfa have been produced with very good yields. Grapes set out on a small acreage appear very thrifty, though they are not in bearing. The undeveloped areas produce a dense tall growth of creosote bushes, some bur sage, cacti, and grass.

This is a soil of very desirable texture. It has a fair water-holding capacity and although it is very permeable it is not leachy. It should prove one of the most desirable soils of the area in which it occurs following the development of irrigation. Like most other desert soils of this region it is low in organic matter, which should be supplied.

ANTHONY FINE SANDY LOAM

To an average depth of 20 inches the surface soil of Anthony fine sandy loam consists of rich-brown or reddish-brown mildly calcareous smooth-textured fine sandy loam. This is underlain to a depth of about 4½ feet by a slightly compact layer which gives moderate effervescence on the addition of weak hydrochloric acid. The next lower material is similar to the surface layer. This is a young soil in which only slight modification occurs in the subsoil. The entire soil is uniform, with the exception of the slight accumulation of lime and the slight compaction of the subsoil. The material is slightly micaceous and is firm but very friable throughout; ma-

terial from any part of the soil may be crushed to an incoherent mass in the hand. This is an alluvial soil derived from granitic rocks in parts of the area and from rocks of mixed origin in other parts.

This soil occurs on the higher fans, in many places between areas of older weathered soils or on slopes between recent soils of lighter and heavier texture. In these localities this soil owes its presence to the intermittent and transient desert streams that have carried the material from mountains and higher fans. Practically all of this soil is in the northwestern and west-central parts of the surveyed area, where it occurs in small, long, narrow tracts or comparatively large bodies of irregular outline.

Areas of Anthony fine sandy loam differ in relief in different parts of the area. Where the soil occurs on the higher fans of the northwest and west-central parts the surface is very smooth and the slope ranges from 20 to 40 feet to the mile.

The undeveloped areas on the higher fan slopes produce a growth of creosote bush, with some bur sage and desert sage. Plantain, 6-weeks' grass, and alfilaria make an appreciable growth following heavy rains.

ANTHONY VERY FINE SANDY LOAM

Anthony very fine sandy loam is very similar to Anthony fine sandy loam. The difference in texture is the only essential difference in the soils.

In sec. 18, T. 2 N., R. 1 W., where this soil joins Mohave fine sandy loam, the deep subsoil conforms to the subsoil of the Mohave soil. A similar area occurs where this soil joins the west and northwest part of the Pinal gravelly loam area in the SE. ¼ sec. 18, T. 2 N., R. 1 W.

This soil supports a thick growth of desert sage, a few mesquite trees in the low spots or along shallow stream ways, and following periods of appreciable rainfall a growth of 6-weeks' grass, Indian wheat, and some alfilaria furnish some pasturage.

This soil is one of the most desirable physically in the area. It handles easily under all farm practices, has a very good water-holding capacity, and should take water easily. It is suited to the production of all crops raised in the vicinity. It is low in organic matter, which should be added.

ANTHONY LOAM

To a depth of 9 inches Anthony loam consists of reddish-brown, very mildly calcareous, slightly micaceous loam which, though very slightly compact, exhibits much pore space. The aggregates are mellow and very easily pulverized between the fingers. Between depths of 9 and 24 inches the material is reddish-brown, slightly compact, mildly or moderately calcareous, gritty, heavy loam of highly mixed origin. The soil aggregates, as in the surface horizon, are crushed with but little pressure. Below this layer is light reddish-brown, firm, but friable, mildly calcareous, silty very fine sandy loam which extends to a depth of about 50 inches. This layer is high in silt and breaks to a smooth rather floury mass with very little pressure. It is underlain by light reddish-brown, firm, but friable, mildly calcareous, rather micaceous very fine sandy loam.

In many places textural variation caused by stratification, particularly in the lower layers, occurs; however, the textural variations are not great or of much practical concern. A greater deviation from the typical material occurs in the soil as mapped in the southwest-central and southwestern parts of the area, where the material is almost purely of granitic origin and contains much angular grit throughout. The subsoil and substratum are more open, allowing more rapid percolation and decreasing the capillarity.

This is a young or recent soil derived from mixed or granitic rock débris that has been transported some distance from its place of origin and deposited by streams and flood waters at or near the lower ends of the intermittent desert streams. The largest area is west of Agua Fria. Many small elongated patches occur to the north between that area and the Atchison, Topeka & Santa Fe Railway. One small area occurs about 1 mile northeast of Marinette, and several are marginal to the recent stream-bottom soils where they join the older alluvial-fan soils from a point about 1½ miles northwest of Liberty, southwest through Buckeye, to south of Palo Verde.

This soil is very smooth and lies on very gently sloping fans that average about 30 feet fall to the mile. Drainage is adequate and favorable to irrigation. The movement of irrigation and drainage waters is moderately slow through the soil in the northern part of the area but moderately rapid in the southwest-central and southwestern parts. The soil is free from harmful accumulations of salts, except in the body 2½ miles northeast of Buckeye where a small area is slightly affected.

Desert areas in the northern part of the surveyed area support a dense growth of mallow, a fairly dense growth of creosote bushes from 4 to 8 feet in height, and a number of mesquite and paloverde trees. The areas in the vicinity of Liberty, Buckeye, and Palo Verde are all farmed, and excellent crop yields are reported. Alfalfa furnishes some pasturage during the winter and spring and yields an average of 400 pounds of seed to the acre. Wheat yields about 20 sacks [1] to the acre and barley about 25 sacks. The land is plowed, usually when moist, is allowed to weather and dry slightly, and is then pulverized to a firm seed bed just previous to planting. No commercial fertilizers are used.

This is a desirable soil under irrigation. If the organic-matter content is built up, better yields will be obtained. The soil is well suited to the production of deep-rooted crops, general farm crops, and truck crops.

ANTHONY SILT LOAM

To a depth of about 8 inches the surface soil of Anthony silt loam consists of rich-brown or pale reddish-brown, firm, but friable, rather micaceous and mildly calcareous, mellow silt loam. This surface layer is underlain by mildly calcareous and slightly micaceous, slightly compact, heavy fine sandy loam of similar color. Below a depth of about 48 inches is very similar material of slightly compact consistence and reddish-brown color, which continues to a depth of more than 6 feet.

[1] The capacity of grain sacks in this area averages about 2 bushels.

This is a comparatively recent soil that has been derived either from purely granitic or mixed rocks. Slight textural differences due to stratification occur in nearly all areas. The body located about 2 miles east of Litchfield Park has a dark chocolate-brown surface soil higher in organic matter than most of the soil. Dark-brown material about 10 inches thick, deposited from muddy irrigation waters, covers the surface of the areas about 2 miles northeast of Liberty and below the Buckeye Canal several miles farther east. In the northern part of the area, where this soil lies adjacent to weathered soils, more compact material underlies it in places at a depth between 4 and 6 feet below the surface.

This soil occurs near both large and small stream ways. It is only moderately extensive and does not occur in any very large tracts. Areas are exceptionally smooth. Those along the small intermittent desert drainage ways have slopes averaging about 35 feet to the mile, and those in the bottom lands along the rivers have slopes of about 15 feet to the mile. Drainage is adequate and favorable to irrigation. The area south of Perryville just above the Buckeye Canal has been subject to poor drainage conditions and is affected by an accumulation of alkali salts. Poor drainage conditions do not arise because of impervious strata in this soil but are owing to impervious strata, at distant points or depths, that impound the underground flow and back the water table into the areas where this soil occurs.

Only a few acres of this soil are being utilized for farming at present. Truck crops do very well. The untilled areas on the higher fan slopes support a growth of creosote bush from 3 to 6 feet in height, some bur sage, cacti, mallow, and a few grasses. Paloverde, ironwood, and mesquite trees thrive along the intermittent drainage ways. The alkali-affected bodies are covered with a growth of desert sage, inkweed, saltbush, jasmine, and mesquite.

This is a desirable soil to cultivate and handle under cultivation and is suited to the production of truck crops and other crops grown in the area.

ANTHONY SILTY CLAY LOAM

Anthony silty clay loam consists of brown or rich-brown, slightly compact, mildly calcareous, silty clay loam extending to a depth of about 10 inches. Although this layer is slightly compact and rather firm, the occurrence of a rather large pore space is characteristic. When fractured the material breaks horizontally, indicating cleavage planes correlative with the layers of deposition of the sediment. This layer is underlain by light-brown compact mildly or moderately calcareous silty clay loam which fractures horizontally, as does the surface soil and which, although more compact, crushes with about the same amount of pressure. This layer extends to a depth of about 4 feet, where it is underlain by rich-brown, compact, mildly calcareous, light-textured loam rich in very fine sand. This material is firm but easily cut with the soil hammer, and the small aggregates can be readily crushed to an incoherent mass within the hand.

Variations occur, owing to the stratification of materials. In many places material of silty clay loam texture continues throughout the entire soil, but in a few places lighter and heavier textured strata predominate.

This soil occurs as rather recent alluvial deposits along small intermittent stream ways. The largest area is in a low drainage way extending from a point about 2½ miles northwest of Litchfield Park to a point where it joins with bottom lands about 7 miles to the south. Two other long narrow tracts occur along similar stream ways in the south-central part of the area. The surface is smooth but in many places is cut by shallow drainage ways. The slope averages about 25 feet to the mile. The surface run-off is well cared for by the presence of drainage ways through which flood waters from high lands pass following rainfalls. Subsoil drainage is slow.

With the exception of a few acres northeast of Marinette, this soil is uncultivated. The undeveloped area supports a growth of mesquite, which grows large and thick along the drainage ways. Thickets of trees 15 feet in height are common. A few grasses, jasmine or squaw bush, and jimmy weed are also common. Under irrigation the soil is better suited to grains and truck crops than to citrus fruits or similar crops that do better on lighter-textured soils in more frost-free locations.

GILA SANDY LOAM

The surface soil of Gila sandy loam to a depth of about 14 inches consists of rich-brown or faint reddish-brown sandy loam. The surface ½-inch covering is slightly laminated, and the entire layer is friable and open. The next lower layer, which continues to a depth of nearly 5 feet, consists of rich-brown, friable, loamy coarse sand. This is underlain by brown or rich-brown, loose and friable coarse sand and sand containing fine gravel. The entire soil is mildly calcareous and contains a large quantity of gritty angular sand fragments derived from granitic rock. The soil departs rather widely from the typical Gila soils in granitic origin, gritty texture, and occurrence on the higher alluvial-fan slopes.

Variations include slightly finer-textured materials present in places in the lower part of the subsoil. The gravelly subsoil condition prevails in a large part of the areas on the higher fans west and northwest of Litchfield Park, near the present intermittent stream ways.

This soil is rather extensive in area and in distribution. It occurs on and along the lower breaks of many of the high alluvial fans that lead from the White Tank Mountains. The materials have been washed from these mountains, carried down the fans, and deposited on the lower fans where ridges have been built up by the deposition of this material clogging the stream ways, causing the streams to become diverted to other courses where similar conditions have developed. The soil also occurs at the lower breaks of fans occupied by older soils where the streams carrying sediments have fanned out and dropped their load. Large areas are west, northwest, and southwest of Litchfield Park and many smaller areas are mapped along the Southern Pacific Railroad from near Norton to within a few miles of Buckeye Station. Two areas are mapped in the southwestern part of the area near Palo Verde.

Areas of Gila sandy loam are exceptionally smooth, and the slopes are uniform and very gentle. Drainage is adequate or excessive in places. The soil is naturally very free from accumulations of harm-

ful salts, but a small comparatively low-lying area about 2¼ miles south of Perryville is slightly affected. Here the underground water table has been forced up near the surface. A small part of the area southwest of Palo Verde is similarly affected.

Less than 5 per cent of this soil is under cultivation, but very favorable yields of alfalfa hay and seed, and of grain are reported. Undeveloped areas on high fan slopes support a dense growth of creosote bushes that grow from 6 to 10 feet in height. Some 6-weeks' grasses, alfilaria, Indian wheat, and less important small plants make considerable growth and furnish some pasturage following periods of appreciable rainfall. A few paloverde, ironwood, and mesquite trees grow along the intermittent washes.

This soil is very easily plowed, cultivated, and irrigated. It is deep and without obstructions to deep-rooted crops. Following development of irrigation, it will probably be a valued soil for the production of citrus fruits and other tender crops and for the early spring production of small vegetables. It does not have a high water-holding capacity and in many places is somewhat leachy. Short runs are necessary, and applications of irrigation water should be small but rather frequent. The soil is very low in organic matter, which should be supplied.

GILA FINE SANDY LOAM

Gila fine sandy loam, as mapped in this area, occurs only in the river bottoms. This soil was in part included with Pecos sand in the early survey of the area.[2] It has probably been modified by deposition of finer-textured sediments since that time.

In typical areas the soil is strictly recent in profile, without modification by weathering. The areas near Gila River are higher in mica and more mellow than other areas. Gravelly or stony areas are shown by gravel and stone symbols. The tract mapped between Skunk Creek and New River in the northeastern part of the area contains a number of gravelly patches, which are leachy. Other parts of this body consist of rather coarse materials throughout and are also rather leachy.

In cultivated areas along the streams the land has been leveled but in much of the soil along Gila River the surface is somewhat hummocky and in places is cut by short, local, drainage ways. The hummocks range from 1 foot in height and 3 feet in diameter to as much as 5 feet in height and 15 feet in diameter. They are round, oval, or elongated and parallel the rivers. They are probably the result partly of wind action and partly of erosion by water. Drainage is adequate in most places. Part of the low-lying areas below the old fans near and west of Norton and a few small areas that join the poorly drained phase of this soil in the Buckeye irrigation district have been subjected to a high-water table and are affected by alkali, as shown on the soil map. Other areas near Gila River are also affected. These areas have been subjected to a high-water table in the past but are now well drained and with but little flooding can be rid of the salts.

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[2] ECKMANN, E. C., BALDWIN, M., and CARPENTER, E. J. SOIL SURVEY OF THE MIDDLE GILA AREA, ARIZONA. U. S. Dept. Agr., Bur. Soils Field Oper. 1917, Rpt. 19: 2087–2119, illus. 1923.

Only a small acreage of this soil is tilled at present. Truck crops and grains are the general crops produced, and they are reported to yield very well. On the lower lands along the rivers arrowweed, jimmy weed, mesquite, and cottonwood and willow trees are common. The alkali-affected areas are covered with a growth of inkweed, jasmine, saltbush, and mesquite.

This is a very desirable soil to cultivate and irrigate. It is deep and friable and offers no obstruction to deep root penetration. It is low in organic matter and could be improved either by the application of organic manures or by growing and turning under green-manure crops. Where the water table is maintained at a depth sufficient to prevent capillary rise to or near the surface, this soil may rather easily be leached of detrimental salts.

Gila fine sandy loam, poorly drained phase.—The poorly drained phase of Gila fine sandy loam differs from typical Gila fine sandy loam in that there are a number of stratifications in the profile, some of which are of heavy texture, averaging clay loam or clay. This phase of soil also differs in having a high accumulation of alkali salts and in many places a high-water table. The surface soil to an average depth of 18 inches consists of mildly calcareous, friable fine sandy loam. Below this depth, heavy-textured compact strata of variable thickness occur, continuing in many places to a depth of more than 6 feet but in other places being interstratified with light-textured friable sands and sandy loams. In places the subsoil material has been modified in structure through the effect of accumulated salts. The horizon of modification, which occurs at variable depths, but in most places about 20 inches below the surface, is rather firmly cemented and comparatively hard for a few inches. When dry it is necessary to strike this layer rather heavily with the soil hammer to cause a fracture. The material breaks into large chunks and appears to have a massive structure. On fresh fracture, many small vacuoles are apparent, but no plant roots penetrate the material. The soil of the horizon is light brown in color, with a number of faint reddish-brown mottles about 3 millimeters in diameter. Below this deflocculated and puddled layer, which is a few inches thick, the heavy stratum continues without any cementation. The texture averages about silty clay loam. When moist the material is cheeselike, and when pressed in the hand it can be much reduced in volume. This stratum is light brown in color and lacks the mottling associated with the cemented horizon. It may continue to a depth of 6 or more feet or it may overlie other strata of heavier-textured or lighter-textured material.

This material probably represents the development of a soil profile during a time when fine-textured materials were being accumulated from slow-flowing water under conditions of poor drainage and alkali concentration. Poor drainage and high water-table conditions exist at present. A rather soft white alkali crust about one-sixteenth of an inch in thickness appears in many places on the surface for short periods following evaporation after showers. In some spots a more persistent hard alkali crust one-eighth inch thick has developed on the surface, and in still other places a dark-colored, de-

flocculated, fluffy, mulchlike material from 1 inch to 4 inches in thickness covers the surface. Each of these accumulations consists principally of a mixture of salts in which sulphates predominate but in which some chlorides and carbonates are present.

One large area of this soil parallels Gila River for a distance of 4 miles from a point south of Buckeye. Other areas are at Norton and east and southeast of Norton at a distance of about 2½ miles. The areas are comparatively low or lie on slight slopes adjacent to low, poorly drained lands of heavier texture.

None of this soil is tilled. It supports a growth of greasewood, inkweed, saltbush, jasmine, jimmy weed, and mesquite.

Reclamation of this soil is not impossible but may be rather costly and slow, as in many places some of the strata are nearly impervious. A system of drainage that will maintain the water table at a depth of 10 or more feet is necessary. Then the land should be bordered and flooded to wash the alkali down and out of the soil.

GILA SILT LOAM

Gila silt loam has a 10-inch surface soil of light-brown, slightly compact, mildly or moderately calcareous, rather highly micaceous, smooth mellow silt loam. This is underlain by rich-brown, slightly compact but very friable, moderately calcareous fine sandy loam, which also is highly micaceous and mellow. The material between depths of 28 and 38 inches is compact, brown, highly calcareous, heavy silty clay loam which contains considerable mica and very fine sand and which is a little tight though it contains considerable pore space. This layer is underlain to a depth of 6 or more feet by brown, very compact, moderately calcareous, heavy silty clay or clay which is so compact and tight that water passes through it very slowly. The entire soil is highly impregnated with mineral salts, and in many places black alkali is present. At certain times of the year, following evaporation of rain, the surface of this soil is covered with a thin crust of white salt.

Many variations in texture and in the depth of the strata occur. In a very few small areas no heavy-textured material occurs in the subsoil. The texture of the surface soil is highly variable in the area of this soil mapped between Liberty and Buckeye. Small flats of loam or clay loam occur among many low hummocks of fine sand and fine sandy loam.

This is a recent soil that has been formed in rather low areas where alkali has been present and poor drainage conditions have prevailed at some time. A puddled condition caused by the presence of black alkali occurs in various strata in many areas.

Drainage is greatly impeded, owing to the puddled condition and the nearly impervious heavy strata. However, much of the water is backed into this soil by impervious strata in other soils. Open drainage ditches, only partly effective, have been dug through parts of the soil between Buckeye and Liberty. The alkali accumulations are very high, in most places more than 1 per cent and in many places more than 3 per cent, an amount that precludes the possibilities of growing any commercial crops. Black alkali in slight or moderate amounts is present in some areas. The soil is not

used for agriculture. It supports a growth of greasewood, inkweed, and iasmine, with some mesquite.

This soil may be reclaimed by flooding and reclamation if the water table can first be lowered. Drainage can be effected only by improving the drainage of other poorly drained lands in the vicinity. This might best be accomplished by a few open drains in combination with a battery of pumps to remove the underground water, keeping the water table from rising or backing into the present poorly drained area. Following lowering of the water table, flooding the land to wash the salts from the soil is necessary. Where black alkali is present, an application of gypsum or sulphur should be made to render the black alkali soluble. Reclamation will be difficult and will take considerable time.

GILA SILTY CLAY LOAM

The surface soil of Gila silty clay loam, as it occurs in this area, consists of a 12-inch layer of dark chocolate-brown, slightly micaceous, smooth silty clay loam. This material is slightly compact and following cultivation forms clods which are easily pulverized to an incoherent mass. The next lower layer, which extends to a depth ranging from 18 to 30 inches but averaging about 24 inches, is similar to the surface material but is slightly more compact. It is underlain by light chocolate-brown or light-brown, heavy silt loam ranging in thickness from a few inches to 2 feet. Below this is sandy loam of faint reddish-brown color which continues to a depth of 6 feet. This material, like the layer above, is firm but very friable and easily broken down between the fingers. The entire soil consists of fine-textured mildly calcareous material. The upper darker layers are moderately high in organic matter.

Slight variation occurs in the thickness of the two upper layers of this soil. In parts of those areas that extend southwestward from a point near Liberty Station to beyond Palo Verde, considerable angular granitic grit from the White Tank Mountains is mixed throughout the soil and is present in large amounts in the subsoil.

This soil has a recent profile that is dominated by stratified stream-laid materials. The dark materials of the surface and subsurface layers have resulted from deposition of sediments from muddy irrigation water. These deposits have been laid on recent lighter-colored materials of the Gila series.

This soil occurs only in the lower-lying bottom lands near the rivers where turbid irrigation water diverted from the rivers has been used. The largest area is around Liberty. The surface is smooth, having been leveled for irrigation. The slope ranges from 10 to 20 feet to the mile. Some of this soil was included in the early survey of the area with Pecos sand and Maricopa sandy loam.

Drainage, so far as it is affected by the profile, is excellent. A number of small areas adjacent to poorly drained areas have been subjected to a high-water table. Slight or moderate accumulations of alkali are shown in these localities on the map accompanying this report. The tract near the southeast extremity of the area is strongly affected by alkali.

This soil is very important agriculturally, and nearly all the areas lying below the Buckeye Canal are farmed. Alfalfa and grains are the principal crops, and truck crops and vegetables are grown for home use. Alfalfa yields considerable winter and spring pasturage and about 400 pounds of seed to the acre. Barley averages about 25 sacks to the acre, wheat about 22 sacks, oats about 75 bushels, and sorghum about 2,200 pounds of seed.

The soil is plowed when moist and cheeselike, is allowed to weather until it crumbles to small angular clods, and is then further pulverized by disking and harrowing until a firm seed bed is prepared. Fields foul with weeds are plowed with a disk plow when dry, the plant roots being turned up to kill the growth.

Potentially this is one of the best farming soils of the area. Its surface soil is rather high in organic matter, and its subsoil is open and friable and well suited to the production of any deep-rooted crop to which the region is adapted.

GILA FINE SAND

Virgin Gila fine sand has a surface soil, about 24 inches thick, of rich-brown, friable or loose, mildly calcareous, micaceous fine sand. This is underlain by a stratum of very similar material of sand texture. This stratum extends to a depth of about 4½ feet, where a light-brown stratum of mildly calcareous and rather highly micaceous silt loam occurs. This stratum, which is about 10 inches thick, is thinly stratified or coarsely laminated. The particles are friable and easily crushed to an incoherent mass. At an average depth of about 64 inches this stratum is underlain by light-brown, micaceous, mildly calcareous coarse sand.

Many small undifferentiated areas of very fine sand and a few of sand have been included in mapping. In places the soil is nearly uniform in texture, and in others many thin strata of different textures occur. A few gravelly areas have been indicated on the map by gravel symbols.

This is a very recent soil formed from sandy material derived from rocks of mixed origin. Distinguishable sand fragments are both sharp edged and rounded. The soil occurs in both large and small areas along the rivers. The largest tracts are along Agua Fria River at Agua Fria and south of that town. Small areas adjacent to Gila River were mapped under the name of Pecos sand in the early survey of the area. The surface is flat and smooth in places but in others is somewhat ridged, owing to deposition, or is hummocky, owing to alteration by winds. Water enters this soil readily, passing through the soil material into the lighter-textured strata below. Drainage is excessive.

At present only a few small areas of this soil occurring within materials of heavier texture are tilled. A few fields have been cultivated in the past but are now abandoned. The soil supports a scattered growth of bunch grass, some creosote bush, and a few other bushes. Along streams cottonwood and desert willow trees are common.

This is a leachy soil which requires much water to produce crops. Under present conditions water can not be obtained cheaply enough to be used profitably on it. The soil is very low in organic matter,

and the addition of green manures or other organic manures would be beneficial. This soil should produce good-quality fruits and early vegetables.

GILA CLAY

Gila clay as mapped in this area is much darker colored than the typical Gila soils and is more nearly representative of the Pima soils of some of the earlier surveys.[3] It is very similar to the dark-colored inclusion of Gila silty clay loam, differing principally in the heavier texture and darker color of the surface soil.

Gila clay is not very extensive. One large area extends southwest from near Liberty to near Palo Verde. Small patches are mapped elsewhere. Areas are smooth, having been prepared for irrigation. The slope ranges from 18 to 30 feet to the mile. Although water penetrates the surface soil slowly, the subsoil allows moderate or rapid percolation. Nearly all the soil, however, lies in a low area where the water table has been forced to or very near the surface, and most of it is poorly drained and affected more or less by alkali salts.

Gila clay is not utilized agriculturally. It supports a growth of greasewood, inkweed, saltbush, and mesquite. It was nearly all farmed at one time, but much of it has been abandoned owing to the rise in the water table and the accumulation of salts. It is a readily permeable soil and can be rather easily rid of detrimental salts if the water table is lowered below a depth of 8 or 10 feet.

M'CLELLAN SILTY CLAY

The surface soil of McClellan silty clay, to a depth ranging from a few inches to 1½ feet but averaging about 10 inches, consists of dark or dull chocolate-brown, smooth-textured, mildly calcareous silty clay material moderately high in organic matter. This surface soil is an artificial layer resulting from deposition of fine sediments from muddy irrigation water diverted from Gila River. It becomes a little darker in color when moist and slightly browner when completely dry. The fine-textured materials lie close together, causing the soil to be rather compact. It becomes cheeselike when moist but has a tendency to break into fine clods as it dries following plowing. Below this recent deposit is reddish-brown, very friable, mildly calcareous, light sandy loam or loamy sand. The sandy material of this horizon appears to be slightly mixed in origin but is high in granitic material. This layer continues to an average depth of 26 inches where a layer of similar material but slightly compacted and containing a few faint lime mottles occurs. This horizon ranges in thickness from only a few inches to about 12 inches and is underlain by moderately compact slightly gritty, pinkish-gray clay loam. This color results from a reddish-brown base color mottled and patched with gray where the lime has accumulated. A few lime-carbonate nodules are present in this horizon, as are also a few reddish mottles probably caused by iron stains. This highly modified subsoil material is from 16 to 20 inches thick and at an average depth of 4½ feet grades into moderately compact but friable, pink-

[3] See footnote 2, p. 20.

ish-brown, slightly gritty, highly calcareous clay loam which differs from the material above in having an even distribution of lime with no mottles or nodules.

This is a soil developed on old alluvial-fan deposits derived principally from granitic material that has been transported only a few miles. The weathered profile is very apparent in the four lower layers that have been capped by a recent deposit of fine-textured material from muddy irrigation water. The small area west of Hassayampa River has a silty clay loam surface soil. In the early survey of the area this soil was mainly included with Maricopa sandy loam. Accumulation of surface sediments characteristic of the McClellan soils has probably taken place to considerable extent since that time.

This soil occurs on the lower parts of the old alluvial fans where they merge with recent-alluvial soils of the lower adjoining river bottoms. The soil occurs principally in one large area averaging nearly a mile in width extending from just northeast of Buckeye to west of Palo Verde. Small areas are mapped west of Hassayampa River and northwest of Coldwater. The areas are very smooth and slope evenly at a rate of about 30 feet to the mile. Surface drainage is good, and subsoil drainage is good or excessive. No harmful accumulations of alkali occur, and unless excessive amounts of underground water are forced up into the soil from lower areas, no artificial drainage should be necessary.

This soil, although not extensive, is very important agriculturally and is one of the main farmed soils of the Buckeye irrigation district. The entire soil is under cultivation, principally to alfalfa and grain. Alfalfa is utilized for winter and spring pasture and later in the season to produce seed. It is cut for hay to a smaller extent. The grain crops also are pastured in the winter months and are later harvested for grain. Some grain and alfalfa are cut for hay and feed on the farm. Dairying is an important industry.

Yields of 400 pounds of alfalfa seed to the acre are common. Barley yields from 15 to 28 sacks and wheat from 10 to 20 sacks. Sorghums are produced to a small extent, with yields of about 2,500 pounds of grain to the acre. Truck crops for local market and home use are reported to do very well.

This soil becomes very hard when dry but is plowed with a moderate amount of power when moist. After plowing it is allowed to weather and dry considerably, when it is disked and worked down into a desirable seed bed. It is comparatively high in organic matter in the surface layer and is capable of heavy production, as compared with unsilted desert soils. It should be well suited to the production of truck crops, which should be rotated with alfalfa and grains in connection with the present prevailing dairy industry.

PINAL GRAVELLY LOAM

The surface soil of virgin Pinal gravelly loam is covered in most places by a characteristic "desert pavement" consisting of a surface layer of rounded water-worn gravel of mixed origin ranging in size from fine gravel to stones 4 or 5 inches in diameter. These overlie a layer, averaging about 8 inches in thickness, of pale reddish-brown, mildly or moderately calcareous, slightly micaceous gravelly loam.

In a few places this layer is noncalcareous on the immediate surface, but in many places it is moderately or highly calcareous owing to the occurrence of particles of calcareous materials which have been brought up from below. The material above the cemented layers is commonly slightly compact but is everywhere friable and easily pulverized. The structural aggregates are easily crushed and approach a single-grain structure. The subsoil is similar in most respects to the material above but differs in that it is highly calcareous and contains many small lime-carbonate nodules and fragments of lime-cemented hardpan. The nodules and fragments range from the size of bird shot to an inch or two in diameter and are very irregular but roughly spherical in shape. This layer ranges in thickness from a few inches to 2 feet or rarely more, but in the greater part of the soil it averages about 6 or 8 inches. It grades into a deeper subsoil layer consisting of a gray or light-gray, firmly cemented, lime-carbonate hardpan that ranges from dense and impervious to partly pervious and less dense material in which there are a few inextensive small cracks. This material extends to a depth ranging from 6 to 25 or more feet.

The gravel of the surface layer has been concentrated on the surface by the removal of the finer-textured material by wind and water. The exposed surfaces of the fragments exhibit a dark-brown or dark bluish-black "desert varnish" or "desert polish" stain. The dark burnished stain exists on nearly every gravel, regardless of the kind of material, and is owing, undoubtedly, to the weathering and climatic conditions characteristic of the region. It is most pronounced on the upper surfaces of the gravel. Much of the lime has been leached from the surface soil, and the upper subsoil layer contains concretionary lime nodules and fragments of a lime-cemented hardpan. The deeper layer of limestonelike hardpan evidences the maturity of a weathered desert soil.

The surface and upper subsoil layers are friable, open, and light in texture, absorb water readily, and allow the growth of certain shallow-rooted plants suited to existing desert climatic conditions. The soil particles of these layers are densely interwoven with many fine plant roots and the deeper cemented horizon contains none or only a few that have matted themselves in tiny cracks.

The soil-forming materials have been derived from rocks of mixed origin that have been transported from the mountains several miles north of the area, with which a part of the alluvial fans join at present and probably all joined during the time of deposition. The original material has been transported and dropped from rather fast-flowing transient streams. The soil has weathered under desert conditions for very long periods, resulting in a mature profile.

This soil is inextensive. Several areas are just north and northeast of Litchfield Park, and several others occur near the boundary in the northeastern part of the area surveyed. The soil occupies the surfaces of the oldest alluvial fans. The tracts in the northeastern part of the area form smooth-surfaced ridges that rise gently only a few inches or a few feet above the adjoining fan slopes. They occur in long narrow strips that extend into the valley and represent the original slope of the fans. The areas near Litchfield Park occupy the tops and to some extent the sloping sides of a number

of smooth-surfaced rolling but somewhat stream-dissected knobs that rise rather abruptly to elevations ranging from 15 to 30 feet above the surrounding valley plain. The relief and material of these knobs indicate that they are remnants of what was once a continuous alluvial-fan surface that joined with the higher fans to the north. The original surface has been dissected by desert streams, and large areas of the original materials have been removed by erosion until now only these knobs remain as remnants of the old fan materials in this locality.

The surface soil is only slightly compact and readily absorbs water, but owing to the character of the rainfall in this region much of the water flows over the surface and down the slope in sheet wash and in small stream ways. The surface drainage and run-off conditions are favorable, but internal drainage, owing to the impervious hardpan, is arrested. Where this soil lies below other lands that may be irrigated, accumulation of seepage waters will be favored by the pervious surface soil and impervious hardpan. In areas of restricted outlets, drains must be installed to open a way for these seepage waters to prevent water-logging and harmful alkali accumulations. Fortunately little of this land lies below other lands that may be irrigated.

This soil, because of its gravelly surface and dense, thick hardpan, is not suited to the growing of commercial crops, and no attempts have been made to farm large acreages. It does not produce much pasturage but supports a scattered growth of creosote bush, averaging between 2 and 4 feet in height, a number of cacti, and a scant growth of plantain.

Pinal gravelly loam, red-subsoil phase.—The 1½-inch surface layer of Pinal gravelly loam, red-subsoil phase, in the virgin condition consists of pale reddish-brown or brownish-red, slightly compact, but friable, noncalcareous, pulverulent gravelly loam of slightly vesicular structure. The gravel in this layer, like that through the lower parts of the soil, is well rounded, owing to water transportation, and is highly mixed in origin and in size, varying from fine to a diameter of 2 or 3 inches, with scattered stones 5 or 6 inches in diameter. As mapped the phase includes a few small stony areas. The gravel consists of a mixture of basalt, granite, gneiss, rhyolite, metamorphosed sandstones, and quartzite rocks in which the basic rocks predominate. The exposed parts of the gravel on the surface are stained by weathering and have developed a characteristic smooth, shiny, dark-colored surface coating known as "desert varnish." In local barren spots and spaces between the widely spaced desert plants they have become thickly accumulated on the surface, forming a so-called "desert pavement."

Below the thin surface layer very similar material continues to a depth of about 7 inches. This layer, however, differs from the surface layer in being mildly calcareous and of fine crumb or slightly granular structure. The subsoil consists of red, moderately calcareous, compact, gritty, or slightly gravelly clay loam of fine granular structure. The upper part of this layer, averaging about 13 inches in thickness, grades abruptly into highly modified deeper material which consists of brownish-gray, compact, highly calcareous gravelly

loam firmly cemented by lime. The large proportion of lime carbonate gives the material a gray color which, however, is highly stained with pink, red, or brown where the soil and gravel are less firmly cemented and less heavily impregnated with lime. This material extends in most places to a depth of 6 or more feet and in a few exposures has been observed to a depth of 20 feet. It can not be penetrated with a soil auger, but a very heavy blow with a pick fractures the material. After being soaked in water a few minutes it breaks into small pieces by crushing within the hand. Water passes into it slowly. In much of this soil west of the Atchison, Topeka & Santa Fe Railway the subsoil weathering is not developed to such a degree and the hardpan is less cemented, more open, and better suited to crops.

This is a very old desert soil that has been derived by weathering in place of alluvial-fan materials transported long distances by water. The surface layer has been leached of colloids, soluble salts, and other easily removable materials, and the subsurface materials are somewhat similarly leached. The subsoil shows a high accumulation of fine-textured material, iron and soluble mineral salts, and lime. The lime has concentrated and firmly cemented the soil and gravel fragments of the lower part of the subsoil.

This soil occurs on old alluvial fans that extend from the area surveyed north several miles to the mountains from which the materials are derived. The fans are very smooth surfaced and slightly ridged and within the area surveyed have a slope of about 35 feet to the mile. Surface drainage is well developed, but internal drainage is impeded by the compact subsoil and hardpan. The soil will drain slowly, but as it lies at elevations where it will not receive seepage water from other irrigated areas serious drainage or alkali troubles should not develop.

Stony areas border Agua Fria River in the northern part of the area and occur in the same vicinity where alluvial fans break away to lower lands. The coarseness of the material indicates deposition by streams of great velocity.

This phase of Pinal gravelly loam is of moderate extent. None of it is tilled at present. It supports a widely scattered growth of creosote bush from 2 to 3½ feet in height, a growth of small bur sage, an occasional bunch of 6-weeks' grass or plaintain, and a few giant, cholla, and other cacti.

This soil occurs in the area for which water is now (1927) being stored and canals are being built for water delivery. Under irrigation the soil is, probably, best suited for the production of alfalfa, grains, and similar crops, rather than for tree crops, although trees may do moderately well. The stony areas are too stony and rough to be made use of under irrigation farming.

PINAL FINE SANDY LOAM

The profile of Pinal fine sandy loam corresponds very closely to that of Pinal gravelly loam. There is, however, greater variation in the depth to the hardpan layer in this soil. This is a very old alluvial-fan soil, the materials of which have probably been transported from the mountains to the north and northeast of the area.

Following deposition of the material from transient desert streams, long periods of weathering have resulted in the present soil with its friable surface soil and more compact upper subsoil and indurated subsoil layers.

On a comparatively low-lying area about one-fifth mile wide in the southern part of sec. 10, T. 2 N., R. 1 W., the hardpan appears to have been eroded and carried away. The soil of this area consists of about 2 feet of friable recent-alluvial fine sandy loam overlying a substratum of greenish-gray compact clay. It does not conform to the Pinal material but was included owing to its small extent. The surface soil of an included low-lying area that crosses the road 4½ miles north and 1 mile east of Litchfield Park is of loam texture, and a large part of the tract extending south from this has a very fine sandy loam surface texture.

This soil occurs largely on the smooth-surfaced lower gentle fan slopes adjoining areas of Pinal gravelly loam near Litchfield Park, and to a less extent on two slightly elevated ridges in the southwestern part of the surveyed area. The surface and upper subsoil layers are rather open and friable, giving good surface drainage. The smooth-sloping relief provides very favorable run-off. Internal or subsoil drainage, however, is effectively prevented, and if any large area of this soil is irrigated, the surplus water must move down the slope over or through the surface soil above the hardpan. Where an uneven surface configuration exists in the hardpan, ponding, water-logging, and alkali accumulation will result unless artificial drainage is provided.

This soil has an upper soil of desirable texture and structure for agricultural purposes. The water-holding capacity is low. The land is suited to shallow-rooted plants under desert conditions but is not desirable for the production of any deep-rooted commercial plants. Patches could be irrigated, and shallow-rooted crops could be grown where drainage troubles do not occur. The soil is now generally free from harmful accumulations of alkali.

At present little of this soil has been farmed, and poor yields have been obtained. The largest part of the soil has only a scant pasture value. The vegetation consists principally of scattered creosote bush, desert sage, mesquite, and plantain.

ROUGH BROKEN LAND

Rough broken land is composed of areas too rough to be cultivated. It includes old alluvial-fan soils, principally Laveen gravelly loam, that have been deeply eroded by intermittent arroyos which have developed a network of steep-sided V-shaped valleys. Only a few areas an acre or two in extent are level and smooth enough to allow cultivation.

This soil occurs mainly in the southwestern part of the area where a number of patches, including one about 1 square mile in extent, have been mapped. One tract about 30 acres in size is mapped on the boundary of the surveyed area 6½ miles west and 4½ miles north of Litchfield Park. Much of the soil is barren or supports a small growth of creosote bush, cacti, and grasses. A growth of paloverde, ironwood, and mesquite trees is common in the arroyos.

RIVER WASH

River wash includes beds of stone, gravel, loose sand, and heavier-textured materials that occupy the lower parts of the flood plains and channels of the larger streams. The areas are periodically flooded and are occasionally modified by deposition and erosion. The rivers and streams erode their channels in places and deposit the materials in other places, changing their courses from year to year. The gravel and stones are waterworn and predominately grayish or grayish brown in color. Most of the areas are barren, but in some localities trees and plants have gained a foothold. Cottonwood trees, willows, bata mote, desert willow, and some bunch grasses grow on these areas. On account of the unfavorable physical condition and the frequency of violent floods none of this class of land is utilized for agriculture, except for the small amount of grazing it affords.

AGRICULTURE

The development of agriculture in the Buckeye-Beardsley area is principally of recent origin, though small acreages of lowlands along Agua Fria and Gila Rivers were cultivated by the prehistoric canal-building Indians that inhabited the valleys of these streams. Following the evacuation of the country by these Indians no further agricultural development took place until about 1867, when settlers entered the valley from the military post at Prescott and started farming in the low flats near the banks of the rivers where water could be easily diverted to the land.

Present agricultural development centers mainly about the Buckeye irrigation district which was organized in 1885. In 1890, 6,000 acres were under cultivation, and hay and grain were raised in conjunction with stock raising. By 1910 the area irrigated had increased to 16,000 acres. It has remained about the same since that time. Dairying, which had become popular, suffered a setback about 1918, when the farmers began growing specialized cash crops, principally cotton. The discouraging slump in the cotton market in 1920 resulted in a change back to dairying, together with some hog production and the growing of alfalfa for seed. At present alfalfa and grains occupy nearly the entire acreage of the district. Sorghum, truck crops, and small acreages of fruit are the other crops grown. Poultry raising is of nominal importance, there being four specialized poultry farms in the district.

Winter pasturing of sheep and cattle is important and provides an income for the farmers. Between 75,000 and 125,000 head of sheep are pastured in the district from November 15 to about March 15. Only a few cattle are brought in for pasturing. The sheep are pastured both on grains and alfalfa. The return to the farmer is between $12.50 and $40 an acre.

Alfalfa is grown on all the well-drained soils of the district. The principal varieties are Common and Hairy Peruvian. The strip border method of irrigation is used, the borders being about 33 feet wide and the runs about one-quarter mile long. Renovation and occasional disking of the old fields is a general practice. The first seed crop, which returns about 60 per cent of the season's seed, is

cut about July 1. During July and August a rest period in the growth of the alfalfa occurs, and no irrigation water is applied. The crop begins growing well in September, when irrigation is resumed. The second seed crop is cut about October 15. The seed is marketed, at present, largely through the Roosevelt Hay Growers' Association of Chicago, but many private sales are also made. Alfalfa-plant diseases and pests have not as yet been serious.

Chief among the grains are bearded and beardless wheat, barley, oats, and sorghums. These crops are grown on all the producing soils of the area, but the heaviest yields are obtained on the heavier-textured soils. Early Baart, Marquis, and club wheats and the 6-row and beardless varieties of barley are the most extensively grown. These grains are fall sown and make sufficient growth in winter and early spring so that pasturing is a general practice. Wheat yields from 8 to 20 sacks, with an average of about 25 bushels to the acre, and barley yields from 15 to 28 sacks, with an average of about 45 bushels. Most of the seed wheat is treated to prevent smut.

Oats are grown on nearly all the producing soils of the district. They return from 12 to 30 sacks, with an average of about 50 bushels to the acre. The grain not used for home feeding is sold, mainly in Phoenix markets. Hegari and Dwarf Yellow milo are the principal sorghums raised. The Dwarf Yellow milo is essentially a grain-producing type. Hegari yields a little less than Dwarf Yellow milo, but is valuable for fodder. Sorghums are grown almost exclusively for grain, which is used as feed for hogs and chickens. Average yields of 2,500 pounds to the acre are reported.

The sorghums are grown on both light and heavy textured soils, often where alkali conditions are adverse to more general crops. If alkali is troublesome, a large amount of irrigation water is run between the rows during July and August. This not only washes the alkali down through the soil but causes the deposition of large amounts of silt from the muddy irrigation waters. Five-eighths of an inch of silt is often deposited from an average irrigation during July and August, and large quantities have been deposited on a field in one season when much water was used in reclamation. As green feed is available the year around, little silage is used in the district.

Truck crops of many kinds do well and are grown for local use on many soils. Commercial truck growing has not been popular, owing partly to the inconvenience of hauling to shipping points, but since the main line of the Southern Pacific has been completed through the district (1926), the acreage of truck crops may be increased. Large areas of well-drained, heavy-textured soil are well suited to truck crops.

A few figs and apricots are grown for home use, and a small planting of pecans is being made on an area of Gila silty clay loam southeast of Buckeye. These trees thrive on recent river-made soils under local climatic conditions and should do well if properly cared for.

Dairying is the chief enterprise of the district. Although a few Guernsey cattle are kept, nearly all the herds are Holsteins. The cattle are pastured much of the year, the pasturage being supplemented by alfalfa hay and grains. Usually barns or permanent shelters are unnecessary for protection from inclement weather.

Hog raising is popular in connection with dairying. The milk is nearly all separated, the cream being sold to the Phoenix creameries and the skim milk fed to hogs, calves, or chickens.

Disk and 2-way sulky plows, disks, harrows, and home-constructed floats are in use. About 20 per cent of the farming of the district is done with tractors, principally of the smaller type, and horses are used to cultivate the remainder of the land. The size of farms ranges from 5 to 1,000 acres, but the 80-acre farm is the most common. No crop rotations are followed. Alfalfa is left from four to eight years and with good care is often left much longer before being plowed and reseeded. No commercial fertilizers are used.

Owing to the prevailing type of farming practiced in the Buckeye irrigation district most of the labor is done by the farmers themselves, work is reduced to a minimum during the heat of summer, and horses are used almost entirely to furnish power. In the other districts where holdings are large and cotton is raised, much summer cultivation is necessary and Mexican laborers are employed. Here mules are used in preference to horses.

In the Buckeye irrigation district nearly all the farmers live on their own farms and little land is rented. Land rental for general farming purposes is about $20 an acre. Land values vary slightly with the type of soil, the location, improvements, and crops, and largely with drainage and alkali conditions. Good producing lands command from $140 to $200 an acre, and similar land which is poorly drained and alkali affected sells as low as $30 an acre.

Traces of early agricultural enterprise are to be seen nearly due east of Litchfield Park. Here a ditch, which headed in Agua Fria River and which was dug cooperatively by farmers, watered about 2,000 acres just north of Coldwater. As Agua Fria River is intermittent in flow, it delivered water to the ditch only at flood periods. Silting of the surface soils on which the muddy waters were applied is apparent to-day, but the ditch is nearly obliterated. Because of the inconstant flow of the stream, the ditch was abandoned. Pumped water from wells now furnishes a more satisfactory means of irrigation in this vicinity.

About 1907 a group of individuals homesteaded 5,040 acres a few miles northeast of Coldwater; in 1908 they constructed the Avondale Canal, and crops of barley, grain, corn, pink beans, and alfalfa were produced. Between 1912 and 1919 further water supply was developed from drilled wells. In 1919 the lands were sold to a land-holding concern. In 1920 nearly the entire area was planted with long-staple cotton. The low price received for cotton that year forced the company into the hands of a receiver, and since that date little farming has been done in this area.

In 1917 the Southwest Cotton Co. began operations at Litchfield Park. Wells were drilled on a part of the tract and a battery of wells was installed about 5 miles to the northeast, near Agua Fria River. At the present time water is supplied to this ranch of 17,500 acres by 48 pumps.

Similar development was made about Marinette by this company in 1920. There are 33 pumps on this ranch, together with a canal that carries some flood water from Agua Fria River. On the Marinette ranch 10,848 acres are irrigated.

Cotton, alfalfa, barley, and some fruit constitute the crops grown on the Litchfield ranch. These are also the principal crops on the Marinette ranch, but 3,000 acres of Sudan grass have just been seeded here.

Both Pima and the shorter-staple Acala cotton are grown, but Pima is favored. In 1927 cotton, nearly all the long-staple Pima variety, occupied 3,800 acres on the Litchfield ranch and 3,300 acres on the Marinette ranch. Cotton picking is done by Mexican labor. Each ranch, Litchfield and Marinette, has a gin to care for ginning the crop. The lint is principally shipped to company mills in Los Angeles and is used in the manufacture of rubber tires and products. Seed from the first picking, before frost occurs, is used for seed. The company supplies much of the local cotton-growing area with pure Pima seed. Surplus seed is sold to local oil mills.

The corn worm is destructive to cotton occasionally. A row of corn is sometimes planted on each border, and the worms, preferring the corn, allow the cotton to get well established. Angular leaf spot, or black arm, has been only slightly damaging. Pocket gophers do some damage. These are either poisoned or trapped.

Alfalfa is the crop second in importance on the Southwest Cotton Co. lands. In 1927 it occupied 3,300 acres on the Litchfield ranch and 3,000 acres on the Marinette ranch. At Litchfield the crop is not used for its seed but is cut for hay. Barley is often disked in alfalfa in the fall and pastured during the dormant season of July and August. Two or three cuttings are made before the dormant season of July and one or two cuttings are made in October or November. A small part of the hay is fed on the ranches, and most of what is sold goes to Los Angeles markets. Yields ranging from 3 to 6 tons to the acre are obtained, the largest crops being grown on the comparatively light-textured soils. Both Common and Hairy Peruvian varieties are grown, the Common being recognized as furnishing slightly better feed and the Hairy Peruvian as sending its roots well into the heavier-textured subsoils, thus opening up these compact strata so that plant food is more easily available and water penetrates better.

Alfalfa on these ranches is left from three to five years, after which the land is plowed and seeded to cotton. If possible the direction of irrigation is changed at right angles, to change the slope. For alfalfa as little fall as possible is desired, whereas with cotton a greater fall is desirable. Twenty-five feet fall to the mile is desired for alfalfa on medium-textured soil types.

On the Marinette ranch 3,000 acres of Sudan grass were planted on newly cleared desert soils. This crop is only in the experimental stage. Being a drought-resistant grass, it has been sown on land where it is convenient to deliver a smaller amount of irrigation water.

Small plantings of citrus fruits, figs, and other deciduous fruits have been made. Results with the citrus fruits and figs have been very favorable but with apricots and plums have been moderate or poor. A diseased condition is responsible for the poor condition of these trees. Crown gall has affected many of the trees, and the nematodes are also detrimental.

Guayule, a rubber plant imported from Mexico, is being tried experimentally on the Litchfield ranch, 8 acres having been planted only recently.

The comparatively lower-lying lands from Gila River north along Agua Fria River are watered by pumping from the underground flow and are cultivated by individuals who have homesteaded or bought tracts of the desert land. Similarly developed areas are located along the highway between Coldwater and Perryville. On these private ranches alfalfa, cotton, grains, grapes, grapefruit, figs, and olives are produced. Alfalfa is grown principally for pasture and hay. Sultanina (Thompson Seedless) and Malaga varieties of table grapes are produced. Very favorable yields of good quality early-maturing fruit are obtained. About 20 acres of grapes are producing at present.

Small plantings of Marsh (Marsh seedless) grapefruit have been made in localities where temperatures are such that little or no smudging or orchard heating for protection from frosts has been necessary. The Marsh grapefruit is grown extensively in the citrus district of the adjoining Salt River Valley area and has proved adapted to soil and climatic conditions. The fruit is large and of superior quality and comparatively sweet flavor. The demand for it is growing.

Forty acres of figs about a mile southwest of Marinette are bearing but have not yet reached full maturity. Other fig trees are about the homes in the irrigated parts of the area. The Kadota is the principal variety. The figs are hardy and well adapted to soil and climatic conditions of the area. The fruit ripens in late May and early June and is sold locally for canning purposes.

One hundred and sixty acres of olive trees 12 years old are about 2½ miles northwest of Marinette. Apricots and peaches were interplanted with the olives and have since been removed because of their poor condition caused by frost and disease resulting partly from poor care. The olives are sometimes damaged by frosts. In 1926, 100 tons of olives were taken from the orchard and marketed at California markets.

Small acreages of various truck crops for home and local use are planted on various farms. Potatoes are rather widely grown and marketed in early spring or summer. A very favorable price is usually received. The yield of potatoes varies largely from year to year, the seasonal weather conditions being the determining factor. Late frosts often nip those planted early and hot weather coming early may result in a poor tuber growth. When weather conditions are favorable, moderate yields are obtained. Strawberries and chili peppers are grown on small acreages. They produce well.

The larger part of the area surveyed is still in the virgin desert condition. The Beardsley irrigation project or Maricopa County municipal water conservation district No. 1, the Roosevelt irrigation district, and the large areas of private lands and smaller acreages of school and public lands are not yet developed agriculturally. These lands, however, especially the lands of the Beardsley irrigation project and those closely adjacent, are important pasture lands for sheep and cattle. In seasons of favorable rainfall a considerable growth of Indian wheat, alfilaria, and a 6-weeks' grass furnishes the principal feeds on which the sheep and cattle graze. These areas are grazed in the winter and spring when feed is available and again during the rainy season of July and August when the grasses spring

up. The sheep and cattle grazed in the lower desert area are driven in from the mountain region to the north, those grazed in this area coming mainly from southeast Coconino County. The quantity of feed varies from year to year, and as part of this area is without water the carrying capacity can not well be estimated. In 1924 an area of 5,596,000 acres of desert land in Maricopa County is reported by the Arizona State Department of Agriculture to have carried an average of one cow to 51.8 acres. A number of other plants characterize the prominent vegetation of these desert lands, but are of little or no value for feeds. Chief among these is the creosote bush, bur sage, paloverde, mesquite, ironwood, and various cacti, such as giant, cholla, barrel, and prickly pear. The areas of low alkali content are not important grazing lands, but support a growth of mixed alkali-indicating plants, such as greasewood, inkweed, seepweed, saltbush, jasmine or squaw bush, mesquite, and jimmy weed.

Surface and general topographic features are so uniform and favorable to irrigation throughout nearly the entire area at present under cultivation that there is little choice in selection of lands for special crops. Fertilizers are not in general use. The lands in the more frost-free areas, however, are of special importance in the production of early annual crops and citrus fruits and other perennials sensitive to frost. Most of the comparatively frost-free areas occupy the highest-lying lands and are still (1927) without water for irrigation. It is the plan of the Beardsley Investment Co., which is developing the Beardsley irrigation project, to have the more frost-free lands planted with the crops (principally grapefruit) that are too sensitive to frost to be grown on lower-lying lands without smudging. The lower-lying lands adjacent to the larger streams and other soils of recent origin are recognized as being valuable truck-growing lands and are used for such crops to a large extent.

Most of the land in the Buckeye irrigation district is farmed by the owners, as are the other privately owned lands. The Southwest Cotton Co.'s lands are farmed under the supervision of a superintendent, ranch foremen, and detail foremen. Although little land in the area is farmed by tenants, most of it has a rental value between $15 and $30 an acre and has a sale value ranging from $130 to $300 an acre, depending on adaptability to crops, distance from shipping points and improved highways, soil, alkali, and drainage conditions, and improvements.

IRRIGATION AND DRAINAGE

The Buckeye irrigation district has adjudicated water rights on Gila River, from which the water is diverted by a temporary dam of rock, wire, and dirt. The dam is located on Gila River a short distance below the mouth of Agua Fria River. The main canal is 23 miles long and has a capacity of 500 second-feet. Approximately 30 miles of laterals are operated by the district; small ditches on the farms are kept by the farmers. In parts of the district the duty of water is low, and large amounts are used in irrigation. For the last four years the average cost to the farmer is reported to have been about $2.50 an acre or 50 cents an acre-foot. Water flows through the main canal constantly. The district lies in a compara-

tively long narrow strip, facilitating a short diversion with rapid delivery of water to the farmers.

Irrigation is almost wholly by the strip border method. Most of the borders are 33 feet wide, and the runs are one-fourth of a mile long. Truck crops, fruit trees, corn, and sorghums are irrigated by the furrow method. The slope is rather steep in much of the district, averaging 30 or more feet to the mile. The irrigation water applied flows rather rapidly, often dropping the coarser sediments and washing the finer material from the heads of the rows and depositing it at the lower ends where the water backs up and stands as it soaks into the ground. This has resulted in noticeably heavier-textured soils for distances of 100 to 250 feet above the lower ends of the fields. During flood periods, especially during July and August when many thundershowers occur in the valley, a large amount of fine-textured and colloidal material is present in the river flow. This muddy water, on application to the land, adds considerable fine sediment to the fields.

Several thousand acres of comparatively low-lying lands of the Buckeye irrigation district are affected with a high water table and such quantities of alkali salts that crop production is precluded. Most of the affected area was impregnated with high quantities of salts previous to irrigation. The rising water table, however, has caused further surface accumulation of salts and has resulted in the abandonment of approximately 3,000 acres. The water table fluctuates to some extent, rising about 2 feet above average in March and April and falling to its lowest point from June to September, when alfalfa is not irrigated. The high water table through the lower lands is caused in part by seepage losses from the main canal, particularly where this canal passes through an area of permeable recent-alluvial soils north and east of Liberty.

The drainage investment in the district at present is reported to amount to $60,000. Nine miles of but partly effective open drains have been constructed. These have lowered the water table in parts of the area through which they pass but have had little effect in other parts. This condition of very slow or inappreciable movement of drainage waters seems to be aggravated principally by an irregular occurrence of a series of stratified layers of compact and comparatively impervious clay or clay loam and in places by a puddled condition of the soils caused by black alkali.

The area of low alkali accumulation occupies an old drainage way through which, it seems, quantities of slow-flowing water have deposited much fine sediment stratified with coarser-textured layers. This low alkali-affected area, although paralleling Gila River, does not drain freely to the river, probably owing to an underground barrier beneath the ridge that separates the area from the river. It seems that a few deep drains opening to the river through this dividing ridge, a partial open drainage system leading to the openings, and a system of intercepting the excess waters before they reach the low area, perhaps a series of pumps, would greatly benefit or control the water table so that reclamation might be feasible.

Irrigation on the Avondale tract near Coldwater started in 1912, on the Litchfield ranch of the Southwest Cotton Co.'s holdings in 1917, and on the Marinette ranch in 1920. Irrigation has been prac-

ticed for many years in parts of the area where individuals have homesteaded or purchased lands. Irrigation water is mainly pumped from underground sources, but part of the water for the Marinette ranch is diverted by gravity through a ditch from Agua Fria River.

The cost of pumping the underground water with electrically operated pumps on the Southwest Cotton Co. lands over a period of about four years has been computed by the company to be $2.01 an acre-foot or $0.0327 to lift 1 acre-foot of water 1 foot in height. The lift here is 61.4 feet.

The pump system of obtaining irrigation water results in the use of a minimum adequate supply with but little loss by seepage. Through the pump district, drainage conditions are good and no drainage developments have been needed or installed. Protection from floods of surface waters breaking into the fields adjoining the desert areas has been found essential, and diversion ditches along the upper sides of fields so located have been constructed. Some work has been done along the intermittent stream that enters Agua Fria River from the northwest about 1½ miles south of Agua Fria. Here the channel has been widened and the banks built up to keep the flood waters from spreading on the adjacent farm lands.

Additional development to provide irrigation water for the remainder of the arable land covered in this survey is being undertaken at present (1927).

According to the Beardsley Investment Co. of Phoenix, the Beardsley irrigation project includes 39,026 acres of desert land in the northwestern part of the surveyed area. The legal water rights are controlled by the Maricopa County municipal water conservation district No. 1. The Frog Tanks Dam, located in Agua Fria River about 18 miles north of Marinette, is just being completed. Water is to be stored in the Lake Pleasant Reservoir and used for power development at the Frog Tanks Dam where it returns to Agua Fria River, being diverted to the main canal at the diversion dam about a mile down the river. A second use is made of the water for power development as it passes through a power house where the canal crosses the river. The main canal is 32 miles in length, the laterals are about 54 miles, and the sublaterals 56 miles. The total cost to the farmer for water is estimated to be between $6 and $7 an acre a year.

The Roosevelt irrigation district parallels the Buckeye irrigation district on the north and includes 37,000 acres of desert lands that are privately owned by a group of individuals. According to the engineers of the district the water supply is obtained by pumping underground waters in a part of the Salt River Valley west of Phoenix. The water is to be purchased from the Salt River Valley Water Users' Association and conveyed in a main canal crossing Agua Fria River east of Litchfield Park, then running southwest following the contour of the land. The district has planned 28 miles of main canal and 100 miles of laterals necessary to deliver the water to the high point of each 40 acres. The main canal will have a capacity of 370 second-feet at the source of supply. A supply of 3¼ acre-feet delivered at the land is planned. The cost to the farmer will vary slightly from year to year with variations in the cost of power, maintenance, and operation and the interest charges and redemption of the bonds.

A payment plan extended over a period of 34 years indicates a charge of $7.50 an acre for the first year, an increase to $11.30 the fifteenth year, and then a decrease to $5.15 the thirty-fourth year. After that a charge of $2.18 for power and $2.50 an acre for maintenance and operation is indicated as the annual charge.

Most of the land of the Roosevelt irrigation district has been homesteaded and is held in small tracts at the present time. There are three large tracts in the district, but the average holding is 103 acres. About 9,500 acres are classed by the district as citrus land, that is, land lying in a comparatively frost-free belt. No poorly drained land has been included and no provisions, other than waste ditches, are being made for drainage.

It is probable following irrigation of the lands of the Beardsley irrigation district and of the Roosevelt irrigation district that waste or seepage waters from these areas will approach the surface in outside lower-lying areas or to some extent in small areas within the districts.

ALKALI

Most of the important soil-forming rocks contain more or less soluble minerals which on the disintegration of the rocks are dissolved and carried from the soil in solution. In arid and semiarid regions in areas of arrested drainage or where the underground waters approach the surface and evaporation occurs, these soluble salts are deposited from solution. These alkali salts (in this report all salts detrimental to crops, whether they are acid neutralizing or not, are referred to as alkali salts) thus accumulate on or near the surface in the zone where crops root and feed, and interfere with the nutritive functions of the plant. The black alkali destroys the organic matter of the soil, corrodes growing vegetation, and affects the soil structure unfavorably by puddling or deflocculating the particles and causing them to run together and form a tough, impervious, hardpanlike layer.

In a small proportion of the Buckeye-Beardsley area harmful accumulations of alkali salts occur. The affected areas are largely the comparatively low-lying lands that have received large amounts of waste or seepage water from adjacent irrigated areas.

In obtaining the data relating to alkali which are indicated on the soil map accompanying this report, a number of tests were made in the field with the electrolytic bridge. The surface foot of soil, a composite of the second and third feet, and a composite of the fourth, fifth, and sixth feet were tested and the percentage of soluble salts in the air-dry soil was determined. Qualitative tests for the presence of black alkali were made by the use of phenolphthalein indicator. The largest part of the alkali-affected area contained a predominance of the white alkali salts, but in a few places black alkali was found present in varying quantities. A sample from a badly affected area of soil about 200 feet west of the southeast corner of sec. 23, T. 1 N., R. 2 W., was sent to the University of Arizona where chemical analyses were made. The results of the analyses are given in Table 3.

TABLE 3.—*Concentration of ions present in alkali-affected soil*

Depth (inches)	Total soluble salt in parts per million	Calcium (Ca)	Magnesium (Mg)	Chlorides (Cl)	Sulphates (SO_4)	Carbonates (CO_3)	Bicarbonates (HCO_3)
0 to 15	3,460	None.	None.	820	750	348	403
15 to 30	4,064	do	do	790	950	624	366
30 to 72	41,595	do	do	3,020	2,475	1,344	488

Table 3 shows that most of the salts are the sodium salts, sodium chloride, sodium sulphate, and sodium carbonate. Where such amounts of carbonates and bicarbonates occur in association with the white alkali salts not only is the soil structure apt to be unfavorable for crop growth owing to puddling and the presence of tight layers, but the concentration of salts is such that only the noncommercial alkali-tolerant plants can thrive.

The first step in reclaiming alkali-affected land is to lower the water table to a depth of 6 or 8 feet below the surface so that capillary rise due to evaporation is greatly reduced or completely stopped. The land should then be flooded so that the water may percolate through the soil, dissolving the salts and carrying them out of the soil in the underdrainage. On lands badly affected with black alkali, gypsum or sulphur must be applied to bring about favorable chemical reaction and render the soil pervious so it can be leached of the soluble salts.

Areas which for all practical purposes are free from harmful alkali concentrations contain less than 0.2 per cent of alkali salts. In these lands there is little danger of harmful concentrations developing except where unfavorable drainage conditions may develop and persist for considerable periods and bring about further accumulation of salts. Other areas are slightly affected and contain appreciable amounts of alkali salts, from 0.2 to 0.4 per cent, but so distributed as to have minor effect on growth of crops. More severely or moderately affected areas contain higher percentages of alkali, usually from 0.4 to 0.8 per cent, so distributed as to have a moderately detrimental effect on the growth of crops. In these areas there are many small barren spots where the alkali concentration is higher than the limits given. Strongly affected areas contain such a large percentage of alkali that the soil is unsuited to the successful growing of crops in its present condition. These areas generally have a concentration of more than 0.8 per cent in the 6-foot section, and in many places the accumulation is as much as 2 or 3 per cent. Such amounts preclude production of all but a few alkali-tolerant plants.

The location of the samples taken for determination of alkali content, with the results of the tests, is shown on the soil map. The amount of alkali is shown in terms of percentage of total soluble salt present, determined in relation to the dry weight of the soil. The percentage in the surface foot and that of the average of the upper 6 feet are shown in fractional form, with the percentage of the first foot represented by the numerator and the average of the 6-foot section by the denominator of the fraction.

The slightly affected areas occur in the comparatively heavy-textured flats or depressions lying below large drainage areas and

bordering lower-lying areas of heavier salt concentration where evaporation has been high and small amounts of alkali have been accumulated in the soil material.

The moderately affected lands contain many fields of spotted growth, where in some places the alkali had accumulated in small amounts and in other places in larger quantities. In such places most of the salts are of the white alkali group and can be washed from the soil if the water table is kept lowered and flooding is practiced. The lands so affected vary widely in texture and character and occur mainly in close association with the more strongly affected areas.

The strongly affected areas are the most extensive areas of alkali accumulation in the survey. Although a part of the old alluvial-fan soils are affected and included, most of the soils of this degree of concentration are of recent origin and contain impervious stratified layers of clay or clay loam. Poor drainage has accelerated the salt accumulation. Both white and black alkali were present in the soils of this grade of concentration, the white alkali predominating and the black occurring in appreciable amounts only in small areas. The black alkali was found to be more common in the locality near and to the east of Norton and to be present in only a few localities and in small quantities southwest of Norton.

Part of these strongly affected soils can be readily reclaimed if the water table is maintained at sufficient depth. The easily reclaimable areas, however, are so irregular in outline and so mixed with the other areas that no attempt has been made to delineate them. Such areas exist where the subsoils are permeable and of light texture, allowing comparatively free movement of percolating waters. In much of the strongly affected area the subsoils are heavy textured and impervious, and in many places there is a puddled layer that becomes hard and compact and appears weakly or firmly cemented on drying. These layers can be drained only very slowly and by the use of large amounts of water.

The practice of flooding alkali lands with muddy flood waters in the Buckeye irrigation district has been beneficial not only in washing the alkali out of the soil but in depositing on the surface large amounts of dark-colored silt low in soluble salts. This layer is favorable for seed germination and young succulent root growth. A part of these partly reclaimed lands has become more highly affected and nonproductive owing to a rising water table. It is needless to attempt reclamation in this area until drainage is installed that will control and keep the water table at a safe depth below the surface.

SUMMARY

The Buckeye-Beardsley area is in Maricopa County, in the south-central part of Arizona. Phoenix, the State capital, 15 miles east of the area, is the nearest city.

The area includes the lands which are farmed at the present time and the adjacent desert lands for which development of a supply of water for irrigation is now (1927) being undertaken. The survey covers 284 square miles, or 181,760 acres, in which are included the Buckeye irrigation district, the Roosevelt irrigation district, the

Beardsley irrigation project, and other large and small company and individual holdings.

The area includes a series of smooth-surfaced alluvial fans and a comparatively small area of bottom lands that lie parallel to the rivers and small streams. Elevations range between 760 and 1,330 feet above sea level. The higher-lying lands of the area consist of the lower extremities of the alluvial fans which extend into the valley from near or distant rugged mountains. These fans unite and form an expansive valley plain of well-drained very uniform lands that are but little dissected by deeply cut streams. The slope is also very uniform and ranges from 20 to 40 feet to the mile. The bottom lands are principally smooth surfaced and very gently sloping, but small areas are slightly choppy or hummocky owing to stream erosion and wind alteration. Gila River forms the southern boundary of the area. Surface and subsoil drainage are very good in most of the area, but a low-lying strip of land paralleling Gila River is poorly drained and affected by high accumulations of alkali salts.

The surveyed area is traversed by two railroads and two through highways. The Southern Pacific Railroad connecting Los Angeles and Phoenix with points east and one highway traverse the southern part of the area, and the Atchison, Topeka & Santa Fe Railway and a highway connecting Phoenix with coast cities and points of northern Arizona traverse the northern part. The population, which is about 2,200, is all classed as rural.

The summers are long and hot and the winters short and mild. The climate is strictly arid, with very low relative humidity and a large daily variation in temperature. Wind velocity is exceptionally low, and snow, hail, fog, and destructive thunderstorms are unknown or very rare.

Agricultural development was begun about 40 years ago in the Buckeye irrigation district, but is comparatively young in the remainder of the cultivated lands. The largest part of the area is yet to be developed. Alfalfa, grains, and cotton occupy the largest acreages at present. Winter vegetables and truck crops, and grapefruit, oranges, grapes, figs, olives, and other fruits of minor importance are produced on a small scale at present but will be of greater importance following the irrigation of the more elevated districts for which water is now being provided. Dairying and poultry farming are important in the Buckeye irrigation district. Individually operated farms average about 80 acres in size in the more diversified farming districts, and companies own and operate large acreages.

The soils of the area are derived either from mixed rocks or granitic rock materials that have been transported and deposited by a number of streams of variable or transient flow. Besides river wash and rough broken land, 23 soil types and 3 subordinate phases, representing 6 soil series, have been mapped.

The weathered soils of the area include those of the Pinal, Mohave, Laveen, and McClellan series, and the recent or but slightly modified stream-deposited soils are represented by the Anthony and Gila series.

This area lies in a decidedly arid region in which irrigation is essential. Large areas are irrigated by pumped water and by diverting gravity water from Gila and Agua Fria Rivers. Irrigation is practiced mainly by the strip border and furrow methods.

Alkali salts occur in small amounts in the lower-lying comparatively heavy-textured soils of the area but are present in injurious amounts in small areas. Excessive quantities of alkali can be removed only by the installation of an adequate drainage system followed by flooding and leaching.

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[PUBLIC RESOLUTION—No. 9]

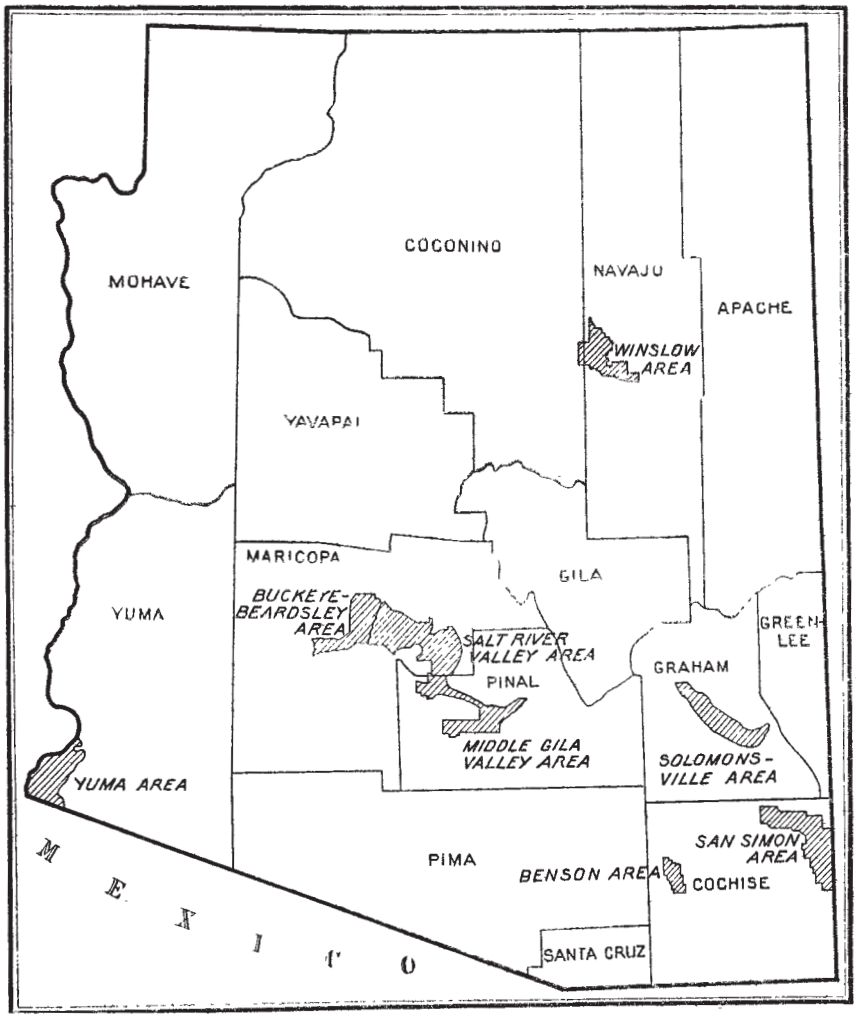
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided,* That in addition to the number of copies above provided for there shall be printed as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils, and on July 1, 1927, the Bureau of Soils became a unit of the Bureau of Chemistry and Soils.]



Areas surveyed in Arizona, shown by shading

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U. S. DEPARTMENT OF AGRICULTURE
BUREAU OF CHEMISTRY AND SOILS
HENRY G. KNIGHT, CHIEF
A. G. McCALL, CHIEF, SOIL INVESTIGATIONS
CURTIS F. MARBUT, IN CHARGE SOIL SURVEY

SOIL MAP

BUCKEYE-BEARDSLEY AREA
ARIZONA

UNIVERSITY OF ARIZONA
AGRICULTURAL EXPERIMENT STATION
J. J. THORNBER, DIRECTOR
G. E. P. SMITH, HEAD, DIVISION OF AGRICULTURAL ENGINEERING

LEGEND

- Anthony sandy loam — Ay
- Laveen sandy loam — L
- Anthony fine sandy loam — Af
- L — Heavy-textured phase
- Anthony very fine sandy loam — Av
- Laveen fine sandy loam — Lf
- Anthony loam — Am
- Laveen gravelly loam — Lg
- Anthony silt loam — As
- McClellan silty clay — Mn
- Anthony silty clay loam — Ac
- Mohave gravelly sandy loam — Ma
- Gila fine sand — G
- Mohave sandy loam — Ms
- Gila sandy loam — Gy
- Mohave fine sandy loam — Ml
- Gila fine sandy loam — Gf
- Mohave loam — Mm
- Gf — Poorly drained phase
- Mohave clay loam — Mo
- Gila silt loam — Gm
- Pinal fine sandy loam — Pf
- Gila silty clay loam — Gs
- Pinal gravelly loam — Py
- Gila clay — Gc
- Py — Red-subsoil phase
- River wash — Rv
- Rough broken land — Rb
- High average concentration of alkali — A

NOTE: *Location of borings and result of field tests shown thus: ● .05/.07. The upper figure shows the percentage concentration in the surface foot. The lower figure shows the average concentration to the depth of six feet.*

CONVENTIONAL SIGNS

CULTURE *(Printed in black)*

- City or Village, Roads, Buildings, Wharves, Jetties, Breakwaters, Levee, Lighthouse, Fort
- Secondary roads and Trails
- Railroads, Steam and Electric
- Bridges, Ferry
- R.R. overcrossings, Tunnel
- Ford, Dam
- School or Church, Cemeteries
- Mine or Quarry, Mine dumps, Made land
- Bluff, Escarpment, Rock outcrop, and Triangulation station
- Stony and Gravelly areas
- Soil boundaries
- Boundary lines (State, County)
- Boundary lines (Land Grant, City or Village)
- Boundary lines (Civil Township, Reservation)
- U.S. township and section lines

RELIEF *(Printed in brown or black)*

- Contours, Depression contours
- Prominent Hills, Mountain Peaks
- Sand Wash, and Sand dunes
- Shore and Low-water line, Sandbar

DRAINAGE *(Printed in blue)*

- Streams
- Lakes, Ponds, Intermittent lakes
- Intermittent streams
- Springs, Canals and Ditches, Flumes
- Swamp, Salt marshes
- Submerged marsh, Tidal flats

The above signs are in current use on the soil maps. Variations from this usage appear in some maps of earlier dates.

Location of Area in Maricopa County

Macy H. Lapham, Inspector, District 5
Soils surveyed by W. G. Harper, U. S. Department of Agriculture, in charge, and F. O. Youngs, University of Arizona.

Scale 1 inch = 1 mile
1 ½ 0 1 2 3 4 Miles

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Field Operations
Bureau of Chemistry and Soils
1927